SPACE RESEARCH IN SWEDEN 1990–1991

Report to COSPAR-Meeting in Washington D.C., USA
28 August – 5 September 1992

Space research in Sweden 1990–1991

Report to COSPAR-Meeting in Washington, D.C., USA
28 August – 5 September 1992

Published by the Swedish National Space Board
Editor: K. Fredga

Cover: Construction drawing of Sweden's next satellite Freja

ISSN 0282-1052
Kommentus 278 2 001

Gotab 95756, 1992

Contents

National Organization of Space Activities

Swedish National Space Board

The Swedish National Space Board (SNSB) under the Ministry of Industry and Commerce is the central governmental agency responsible for national and international space activities in Sweden including all aspects of remote sensing. For the research programme the Board receives funds from the Ministry of Education and Cultural Affairs. The Parliament, the Swedish National Board for Industrial and Technical Development and Defence Data Systems Agency as well as industry and the scientific community are represented on the Board.

The responsibilities of the Board include:

- initiating research, development and other activities connected with the Swedish space and remote sensing programme,
- coordination of Swedish activities within the fields of space technology and research as well as remote sensing,
- distribution of government appropriations for Swedish space activities,
- authorization and supervision of space activities in accordance with space law
- maintaining contacts with international organizations and institutions operating within the field of space activities and remote sensing.

The Board is responsible for the planning and the coordination of Sweden's participation in the programmes of the European Space Agency (ESA).

The Board has advisory committees for science (incl. microgravity), remote sensing and industrial policy respectively. Below members of the Board, the science and remote sensing committees are listed.

Members of the Board (April 1992)

Prof K Fredga, Chairman
Mr L Ag
Mr G Björk
Prof B Aronsson
Mr S Håkansson
Mrs E Westberg
Prof S Svanberg

Science Committee (April 1992)

Prof B Hultqvist, Chairman
Dr M von Glehn, Secretary
Prof L Block
Dr B Brandt, co-opted member
Dr T Carlberg
Prof A Egeland
Prof S Rundqvist
Prof R Pellinen
Prof B Rönnäng
Prof G Tibell

Remote Sensing Committee (April 1992)

Mr L Ag, Chairman
Dr M von Glehn, Secretary
Prof J Askne
Dr S Bodin
Mr B Wulf, co-opted member
Prof S Jaakkola
Prof R Kuittinen
Mr S Norberg
Prof S Svanberg
Prof L Wastenson
Mr S Zenker

The technical implementation of the national programme is mainly contracted by the Board on an annual basis to the state owned Swedish Space Corporation.

The Swedish space budget for the last fiscal years are given below in million SEK, 1 US$ = 6 SEK)

Fiscal year	1989/90	1990/91	1991/92
International programmes	319	405	462
National programmes	100	106	103
Total	419	511	565

Director General is Prof K Fredga, also National Representative to Cospar.

Address: Swedish National Space Board, P.O. Box 4006, Albygatan 107, S-171 04 Solna, Sweden

Swedish Space Corporation

The principal responsibilities of the Swedish Space Corporation (SSC) are:

- the technical implementation of the Swedish space and remote sensing programmes,
- to conceive, specify, and procure satellites for applications and space science research including overall project responsibility for the satellites,
- to operate the ESRANGE sounding rocket range and satellite ground stations,
- to perform systems management and engineering for complex high technology programmes,
- to receive image data from remote sensing satellites at Esrange. To process and analyze all types of images for different applications and customers all over the world,
- to develop and supply operational remote sensing systems for maritime surveillance and environmental control.

The Swedish Space Corporation has two establishments, one at Esrange, Kiruna, and the other in Stockholm. The main office is in Stockholm.

Managing Director is Mr L Lübeck

Address: Swedish Space Corporation, P.O. Box 4207, Albygatan 107, S-171 04 Solna, Sweden

Association of Swedish Space Scientists (SRS)

Active space scientists are members of this group, the main task of which is to provide a forum for discussions on priorities and joint projects within the scientific programme.

Dr T Carlberg is secretary of the group.

Address: University of Sundsvall, P.O. Box 860, S-851 24 Sundsvall, Sweden

International Cooperation

Within ESA (European Space Agency) Sweden participates in the mandatory basic and scientific programmes, in the ARIANE launcher project as well as Sweden participates in the programmes pertaining to earth observation, space transportation, telecommunication, space station and platforms, and microgravity.

The Swedish contribution to ESA for the Fiscal year 1991/92 is about 386 million SEK.

Bilateral scientific cooperation between Sweden and the US is carried out under an agreement with NASA.

Similarly scientific cooperation is carried out with the CIS under a Memorandum of Understanding with the Intercosmos Council of the Soviet Academy of Sciences.

Bilateral cooperation work on space science and applications, primarily the SPOT-programme, is carried out between Sweden and France under an agreement with Centre National d'Etudes Spatiales, CNES.

Sweden and Germany are cooperating on i.a. the scientific satellite Freja, which is to be launched in October 1992.

Memoranda of Understanding have been concluded as basis for co-operation with Austria, Canada, India and the People's Republic of China. Sweden is also engaged in other bilateral cooperative projects with Denmark, Finland, Italy, Japan, the Netherlands, Norway, Switzerland and the United Kingdom.

Sweden is a member of Intelsat, Eutelsat, Inmarsat and Eumetsat.

National Scientific Space Programmes

The scientific activities of the Swedish research groups are mainly:

Magnetospheric and ionospheric physics, in particular measurements of charged particles and electric and magnetic fields using satellites, sounding rockets and balloons.

Groups:
- Swedish Institute of Space Physics, Kiruna
- Swedish Institute of Space Physics, Umeå
- Swedish Institute of Space Physics, Uppsala
- Dept of Plasma Physics of the Alfvén Laboratory, Royal Institute of Technology, Stockholm

Study of the upper atmosphere (80-150 km) in particular atmospheric processes and composition at high latitudes using sounding rockets.

Group:
- Dept of Meteorology, Stockholm University

Astrophysics, in particular studies of solar and stellar UV radiation and IR studies using satellites, sounding rockets and balloons

Groups:
- Lund Observatory, University of Lund
- Stockholm Observatory, Stockholm University
- Astronomical Observatory, Uppsala University
- Onsala Space Observatory, Chalmers University of Technology, Gothenburg

Material sciences, in particular solidification processes of metals, diffusion processes in liquid metals and crystal growth in microgravity using sounding rockets.

Group:
- Dept of Casting of Metals, Royal Institute of Technology, Stockholm
- University of Sundsvall, Sundsvall

Life sciences, in particular studies of human physiological processes in microgravity.

Group:
- Environmental Physiology Laboratory, Karolinska Institutet, Stockholm

Biophysics, in particular electrophoretic and protein crystal growth studies in microgravity.

Groups:
- Dept of Physical and Inorganic Chemistry, Chalmers University of Technology, Gothenburg

Remote sensing, in particular microwave radiometry, spectral signatures and image analysis using satellite images and registrations from airborne or landbased sensors.

Groups: – Dept of Radio- and Space Science, plus the Millimetre wave group, Chalmers University of Technology, Gothenburg
- Remote Sensing Laboratory, Dept of Physical Geography, Stockholm University
- Remote Sensing Laboratory, Dept of Physical Geography, University of Lund
- Dept of Physics, Lund Institute of Technology
- Remote Sensing Laboratory, Swedish University of Agricultural Sciences
- Centre for Image Analyses in Uppsala, Uppsala University

(note: several groups are engaged in research concerning remote sensing; only the largest and most active groups are listed here.)

Satellites

Viking – Sweden's first satellite

The scientific satellite Viking has been the largest individual project within the national space research programme.

Viking was launched by the Ariane launcher from Kourou 1986. After 444 days Viking stopped functioning due to gradually decreasing power generation.

The scientific objective of the Viking satellite was to study the ionospheric and magnetospheric phenomena at high geomagnetic latitudes in the altitude region up to about two Earth radii. Simultaneous measurements were made of electric and magnetic fields, particle distributions, plasma composition and waves as well as imaging in the ultraviolet of the aurora beneath.

Viking was operated from Esrange, Kiruna, where the telemetry data from the satellite were received and processed on a real time basis. Viking has yielded scientific results which go far beyond expectations. Also from an industrial point of view Viking was a success as it proved that an advanced scientific satellite does not necessarily have to be expensive.

Freja – Sweden's next scientific satellite

Freja is planned in cooperation with Germany to be launched "piggyback" on a Long March 2 C rocket from Jiuquan Satellite Launch Center in China in October 1992 in a lower orbit than Viking, i.e. in the lower part of the region where there is an interchange or interaction between magnetosphere and ionosphere.

The satellite will weigh 259 kg at launch. The orbit will range in altitude

between 600 and 1 720 km. The inclination of the orbit is 63 degrees. The scientific –mission of Freja has many similarities with that of Viking. The auroral zone is thus the "mission target" and the satellite will make high-resolution measurements in the upper ionosphere and lower magnetosphere. The Freja design strives to provide substantially higher data rate than used on Viking.

Freja will be launched during a period of intensive solar activity while Viking was carrying out its mission during a period of low solar activity. This gives an opportunity for interesting comparisons.

Odin

Odin is a planned Swedish satellite for spectroscopic studies at submillimetre wavelengths of astronomical objects and processes in the Earth's atmosphere. The Odin spacecraft is designed to serve both astronomy and aeronomy. Major scientific issues relate to star formation processes, interstellar chemistry and atmospheric ozone balance. Odin is planned to be launched in 1996 with an operational life-time of two years.

Impact

There are also preliminary plans to embark on a multisatellite project IMPACT (Investigation of **M**agnetospheric **P**article **Ac**celeration and **T**urbulence) in international cooperation.

Other Satellite Projects

PROMICS are joint Swedish-Russian experiments onboard PROGNOZ-satellites. The first PROMICS experiments were launched 1978 and 1980. A third PROMICS-experiment is planned for launch within the Interball-concept.

The Institute of Space Physics in Kiruna participated with two hot plasma experiments (ASPERA) onboard the USSR space probes (Phobos I and II) to Mars launched in July 1988, from Baikunur. In spite of the probe damages, the Swedish research group obtained valuable data from Phobos II during its life time. This research group will also be involved in the planned russian project Mars -94.

The Institute of Space Physics in Kiruna also participated in the development of a particle experiment for the ESA spacecraft Ulysses, launched in October 1990.

The three magnetospheric groups are involved in the Cluster project in the Solar Terrestrial Science Programme, the first cornerstone in ESA space science program Horizon 2000.

The Stockholm Observatory and the Astronomical Observatories in Lund and Uppsala participate with several guest investigator programmes on the International Ultraviolet Explorer (IUE) satellite launched in January 1978 and still operating. The Stockholm Observatory also takes active part in the ESA satellite project Infrared Space Observatory (ISO) in the construction of the infrared camera. Several astronomical groups are actively involved in the ESA satellite projects Hipparcos and Hubble Space Telescope as concerns observation and data analyses.

Sounding Rockets and Balloons

Swedish sounding rocket and balloon launches have been carried out since 1961 from Esrange, most of them as international cooperative projects.

The Swedish sounding rocket and balloon programme is concentrated on four main areas:

- magnetospheric and ionospheric physics
- upper atmosphere physics and chemistry
- astrophysical infrared studies
- material, fluid and biosciences in microgravity

The Swedish Space Corporation is responsible for the technical execution of the projects as well as the operation of Esrange.

The following institutes participated in the sounding rocket and balloon programme during 1990, 1991 and 1992.

MISU	Department of Meteorology, Stockholm University
RIT-M	Department of Casting of Metals, the Royal Institute of Technology, Stockholm
SOS	Stockholm Observatory, Stockholm University
CTH	Chalmers University of Technology, Gothenburg

The following campaigns were carried out at the Swedish sounding rocket and balloon range, Esrange from May 1990 up to April 1992:

Payload designation	Launch date	Swedish experimenter
PIROG 4	1990-05-22	SOS
SPINRAC-test	1990-05-30	test flight
PIROG 5	1990-08-27	SOS
MAXUS-test	1990-11-25	test flight
MAXUS	1991-05-08	CTH
DECIMALS A & B	1991-08-09	MISU
PIROG 6	1991-08-31	SOS
MASER 5	1992-04-08	RIT-M, CTH

Another Swedish **MA**terial **S**cience **E**xperiment **R**ocket (MASER) was

successfully launched from Esrange in 1992. The payload contained modules for material, fluid and biosciences with experiments from Europe and Japan.

For projects requiring an apogee of 800-1000 km an Attitude Control System is necessary to decrease impact dispersion. A development of this new **SPIN**ning **R**ocket **A**ttitude **C**ontrol (SPINRAC) system started 1986 and was used in two testflights from Esrange in May and November 1990.

ESA has ordered microgravity experiments utilizing long duration sounding rockets. MBB-ERNO and SSC in a German-Swedish joint venture offers this launch service in the MAXUS program. A single stage Castor 4B motor with a guidance system derived from SPINRAC gives the 780 kg payload a microgravity time of 14 minutes corresponding to an altitude of 800 km. Sweden is responsible for the guidance system, interstage structure, fins and the facilities and operations at Esrange. Both parties offer experiment modules in competition.

The first flight took place in May 1991. However, due to a malfunction in the motor Thrust Vector Control system the flight failed after 46 sec. The failure has been identified and corrective actions have been implemented.

The research programme in Atmospheric Physics at the Department of Meteorology, Stockholm University is concentrated on studies of the upper atmosphere in particular the photo-chemistry and transport of atomic oxygen, nitric oxides etc, at arctic latitudes during summer. Experimental studies are conducted mainly by means of optical measuring technique with rockets and ground-based facilities.

During July-August 1991 a **N**octi**L**ucent **C**loud (NLC) campaign was carried out at Esrange in extensive international cooperation with the launch of 21 sounding rockets, balloons and ground-based and airborne observations.

The Stockholm Observatory is running a high altitude balloon experiment comprising a 30 cm stabilized IR telescope equipped with a liquid helium cooled spectrometer. The scientific aim is to make wideband observations of interstellar far infrared emission lines. A couple of attempts have been partially successful.

A second generation platform of the **P**ointed **I**nfra**R**ed **O**bservation **G**ondola, PIROG MK II, was launched in 1990. The launch was successful and valuable scientific data were delivered during the 12 hours flight duration. However, the recovery failed and the balloon drifted into Russia.

A new PIROG MK II was manufactured and was launched in September 1991. During the 14 hours flight duration SOS successfully carried out the entire planned scientific programme. The gondola was this time

safely recovered and returned to Esrange.

Next balloon gondola equipped with a 60 cm telescope will be launched from Air sur l'Adour in France 1993.

In the next section the different research groups present their programmes in more detail.

Space Research Group

Swedish Institute of Space Physics – Kiruna Division

Address: Swedish Institute of Space Physics, Box 812, S-981 28 Kiruna, Sweden

Prof Bengt Hultqvist
Prof Rickard Lundin

On July 1, 1987 the name of Kiruna Geophysical Institute was changed to Swedish Institute of Space Physics (in Swedish: Institutet för rymdfysik, IRF). IRF consists of four divisions, the Kiruna Division, the Laboratory of Mechanical Waves, the Umeå Division, and the Uppsala Division. The main office of IRF is located in Kiruna.

The scientific investigations carried out at IRF in Kiruna (geographic location 67.84°N, 20.41°E) are mainly concerned with phenomena in the upper atmosphere and planetary magnetospheres. Ground based equipment including EISCAT as well as satellite instruments are extensively utilized.

At the Institute a number of routine measurements are carried out. These include measurements of the geomagnetic field (standard and storm recordings), optical aurora (all-sky camera), ionospheric ionization (ionosonde and riometer 30.0 MHz), and infrasound waves. Continuous recording is also carried out of seismic activity[1], radioactivity[2], and solar radiation[3].

Some of the data obtained are published in Kiruna Geophysical Data which is distributed to some 300 institutes, libraries, and scientists all over the world.

The Ionospheric Observatory at Lycksele (64.7°N, 18.8°E) is operated by IRF-K. The instrumentation in Lycksele includes for example magnetometer, all-sky camera, auroral spectrograph, riometer, ionosonde, and photometer.

The Kiruna Division has participated with experiments on 41 sounding rockets and 10 satellites during the period 1964–1991. The main purpose of these experiments has been to study hot magnetospheric plasma. Of particular interest has been the acceleration and precipitation mechanisms and the interaction with the cold ionospheric plasma.

[1] Supervised by the Institute of Seismology, University of Uppsala
[2] Supervised by the Swedish Defence Research Establishment
[3] Supervised by the Swedish Meteorological and Hydrological Institute

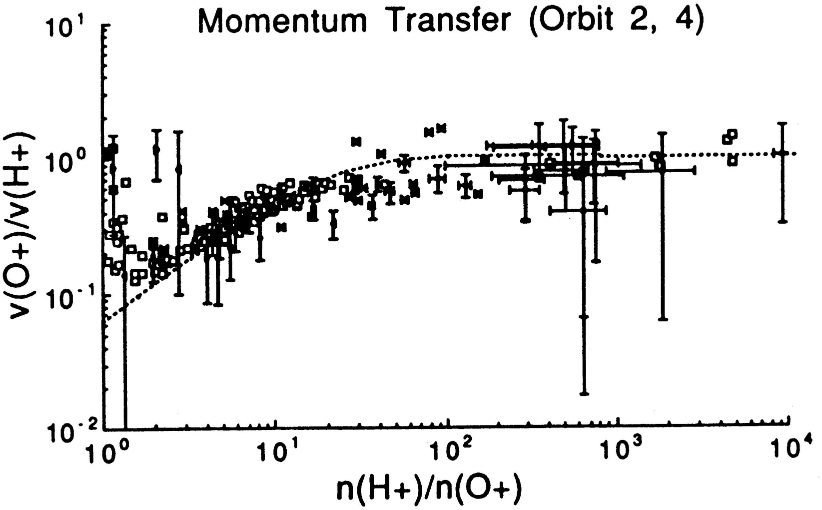

Fig 1. Scatter plot of O^+ and H^+ density and velocity ratios compared with a model mass-loaded ion pick-up for two Phobos-2 deep tail crossings (marked by different symbols). Dashed curve gives the theoretical mass-loaded ion pick-up acceleration.

Activities during 1990 and 1991

Satellite experiments. The studies of ion and electron distributions in various magnetospheric regions using the unique data base that the Swedish Viking satellite provided have continued. Our knowledge about acceleration and heating processes has increased significantly. Some of the topics that have been investigated in detail are dayside auroral phenomena, precipitation at high latitudes and, perhaps the most important one, the time varying properties of the auroral particle acceleration processes.

The hot plasma instruments, ASPERA, on board the two Phobos spacecraft, launched in July 1988, were designed to measure electrons and positive ions in the energy range 0.001 to 25 keV. New important discoveries, from the ion composition results of the Martian plasma environment and the solar wind interaction with the Martian topside atmosphere and ionosphere, have been published.

IRF-K is participating as Co-Investigator in the energetic ion composition experiment (EPAC) on the Ulysses spacecraft, launched in October 1990. The Institute is also Co-I in the Giotto project. The Giotto spacecraft was reactivated and the experiments tested during Spring 1990. A fly-by of a comet is planned to take place in 1992. IRF-K is also Co-I in two of the Cluster experiments and the Polar CAMMICE experiment.

Electron and ion composition spectrometers (MATE and TICS) for the Swedish/German satellite Freja have been manufactured. Development

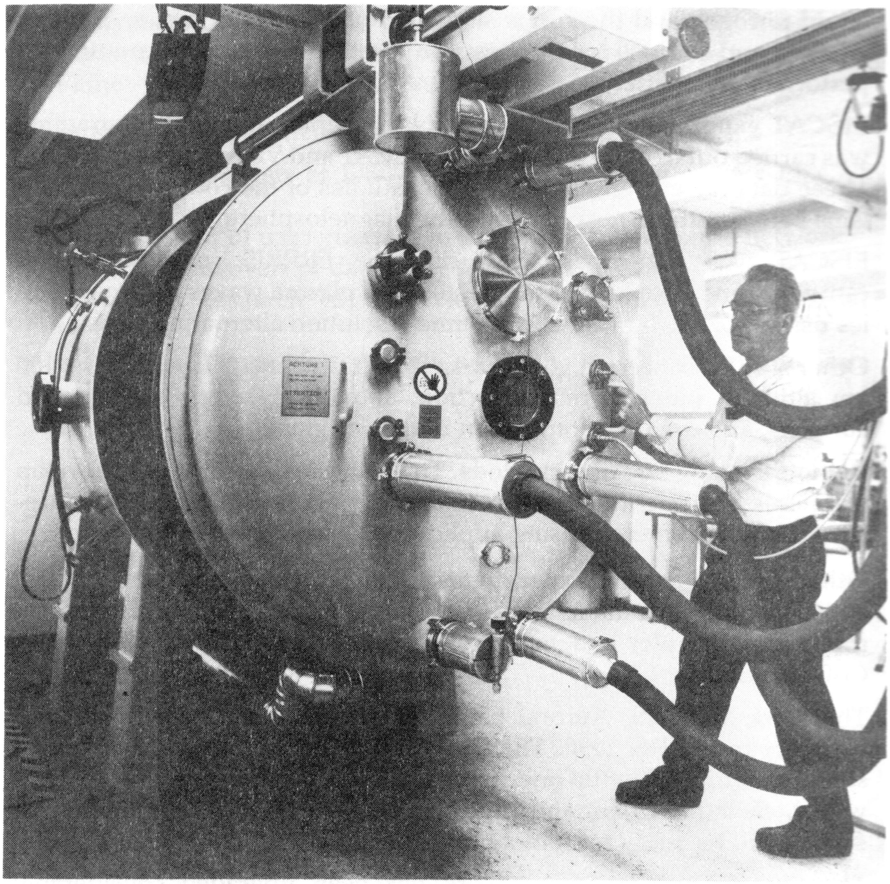

Fig 2. The new space simulation test facility at IRF in Kiruna.

of a new measurement technique has been a major task for the technical staff at the Institute during 1991. Freja shall provide high resolution measurements of auroral processes.

Interball is a mission consisting of two satellite pairs scheduled for launch in 1993. IRF-K is participating with a plasma experiment for positive ions and electrons, PROMICS-3. The instruments have been built and the intensive test period has started.

The development of instruments for the Mars-94 project has started. IRF will contribute with an ion and neutral particle imager experiment for remote and in situ investigations of processes associated with the interaction between plasmas and neutrals near the planet Mars.

A new space simulation test facility has been installed at the Institute. The vacuum chamber is Ø1.5 x 2 m. The inner surfaces can be cooled by

liquid nitrogen and the sun is simulated using special lamps. Thermal vacuum and thermal balance tests on satellite instruments can now be performed in a better way.

EISCAT experiments. During the Viking period a special programme was carried out to make coordinated EISCAT and Viking measurements. These data have been used in several studies of the coupling mechanisms between the ionosphere and the magnetosphere.

EISCAT was also operated during the ERRRIS sounding rocket campaign and provided measurements of plasma waves and instabilities using, for the first time, high time resolution alternating codes.

Other studies concern e.g., enhanced electron density layers below 100 km altitude, ionospheric convection, sporadic E-layers, field-aligned currents, and the ion composition in the F-region.

Remote sensing by radio methods. The Institute is underway to develop the necessary scientific background and make a substantial advancement in radar remote sensing applications and related areas.

Other ground based experiments. The optical instruments at IRF include a monochromatic TV-system, single etalon Fabry Perot interferometer and Doppler imaging system (in collaboration with University College London, UK).

The work on ALIS, Auroral Large Imaging System, started with full intensity in the Fall 1990. The Swedish part of ALIS will consist of 14 stations equipped with one or two CCD-imagers, interference filter wheel, elevation drive, and control computer. During 1991/92 the first station will be ready for remote operation.

The Swedish ionosonde network has been upgraded considerably during the report period.

Plans for 1992 and beyond

In the near future our efforts will be concentrated on the following tasks.

Satellite programme:

- Continued analysis of data from the hot plasma experiments on Viking and Phobos.
- Assembly, testing, and calibration of the hot plasma instruments for the Freja satellite project. Launch in October 1992.
- Testing, and calibration of the PROMICS-3 ion composition instrument for the Interball mission.
- Development, manufacturing, and testing of the ion and neutral particle imager experiment for the MARS-94 mission.
- Participation as Co-Is in the experiments CAMMICE on board the POLAR spacecraft and CIS, and RAPID on board CLUSTER.
- Participation in the continued work using the Giotto spacecraft.

- Analysis of Ulysses data.
- Continued work on planning new satellite experiments e.g., for the Planet-B, Equator-S, and IMPACT missions.

Ground based experiment programme:

- Continued analysis of EISCAT data and planning of new EISCAT campaigns.
- Development of user interface to the Swedish ionosonde network.
- Continued analysis of data from other ground based instruments.
- Continued research in the field of remote sensing with radar methods.
- Installation, tests of new stations in the ALIS system and data analysis.

Swedish Institute of Space Physics – Umeå Division

Address: Swedish Institute of Space Physics, Umeå Division, University of Umeå, S-901 87 Umeå, Sweden

Dr Kjell Rönnmark

The research at the Umeå Division concerns space plasma theory, with an emphasis on plasma waves and wave particle interactions in the magnetosphere. Much of the work is connected to satellite projects, and involves a close cooperation with scientists from IRF-K and IRF-U. The location of IRF-Um within the Umeå University provides valuable contacts with students and researchers from other fields.

During the last few years a variety of energetic upflowing ion and electron distributions have been observed above the Earth's auroral zones by satellite and rocket experiments. Several theories have been suggested whereby, at least in principle, waves or static electric field structures observed in the magnetosphere may produce energetic particle distributions similar to those measured by spacecraft. One of the major aims of the research in Umeå is to establish which of these mechanisms is (or are) most likely to be important in practice.

An important link between wave observations and theory is provided by the wave distribution function (WDF), which describes the distribution of wave energy in wave vector space. A general method for reconstructing the WDF from observed frequency spectra has been developed in Umeå and applied to wave observations made by Viking in the auroral acceleration regions. Theories for wave propagation in weakly inhomogeneous plasmas can be based on the concept of a wave distribution in phase space.

Investigations of data from the Viking and DE 1 satellites have shown that local transverse ion energization often occurs near the equatorward edge of the polar cusp/cleft region. This ion heating is closely associated with the presence of low-frequency broadband waves.

In addition to upgoing ion distributions there are several recent observations of upflowing energetic electron distributions. Many of these observations include distributions with enhanced fluxes at keV energies near the edge of the upward losscone. These distributions usually occur at altitudes of several thousand kilometers on auroral field lines.

A European Network for Numerical Simulation of Space Plasmas has been formed in order to coordinate simulation and theory studies related to the Cluster project. The project is supported within the SCIENCE programme of the EEC for three years from January 1991. The Umeå group is mainly involved in the development of software instruments, corresponding to the EFW/STAFF experiments on Cluster.

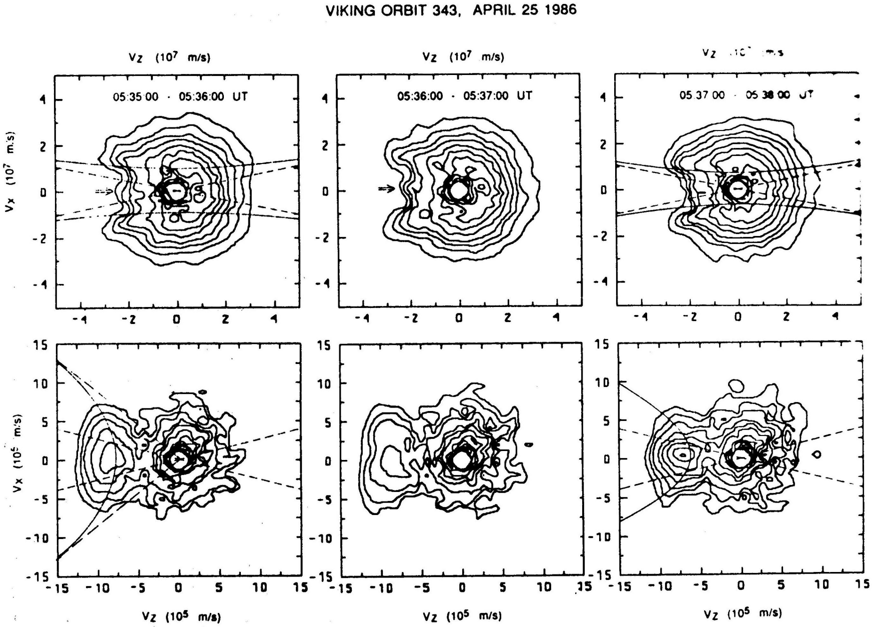

Fig 1. Contour plots of electron (top panels) and ion (bottom panels) distribution functions in velocity space taken by the Viking hot plasma experiment at an altitude of 11700 km. Data show upward electron conics in a region with an ion beam.

Plans for 1992 and beyond

- Continued analysis of satellite data
- Development of wave particle interaction theories related to Viking results, including theories of heating and acceleration of charged particles.
- Further development of the method for reconstruction of wave distribution functions, and further applications of this method.

Swedish Institute of Space Physics – Uppsala Division

Address: Swedish Institute of Space Physics, S–755 91 Uppsala, Sweden

Prof Rolf Boström
Prof Georg Gustafsson

The Space Physics Group at the Uppsala Division of the Swedish Institute of Space Physics studies various aspects of magnetospheric physics. Satellite experiments are performed to study the role of plasma waves in the magnetospheric processes and to map the plasma density and temperature distribution. The principal experimental technique is differential probe measurements of the electric potential variations (using probes in voltage mode) and of plasma density and temperature variations (using probes in current mode). Topics studied experimentally and theoretically include the generation, propagation, and damping of waves, wave–particle interaction including particle acceleration, wave–wave coupling, solitary waves and turbulence. Theoretical work is also done on the boundary layers of the magnetosphere and modelling of the magnetosphere. Within the Uppsala Division of the Swedish Institute of Space Physics, the Space Physics Group interacts with the Heating Group, studying non–linear wave interactions in the ionosphere using powerful radio waves, and the EISCAT Group, studying plasma and geophysical processes in the auroral ionosphere and ionosphere–magnetosphere interactions using the incoherent scatter radar technique. Close collaboration also takes place with other groups in Sweden and around the world.

Activities during 1990 and 1991

Viking. Much of the scientific work during the last few years has been based on the very rich data set collected by the wave experiment on Viking, the first Swedish satellite, which was launched in 1986. The wave experiment consisted of two parts, where the Uppsala group was responsible for the lower frequency measurements and the Danish Space Research Institute for the higher frequency measurements. Groups in France and USA also contributed to the experiment.

The low frequency wave measurements, based on the probes on the 40–m booms, turned out to be ideal for diagnostics of solitary structures and weak double layers found in the auroral acceleration region. These structures, on the Debye and ion gyro radius spatial scale, are of interest as a basic plasma physics phenomenon, and as a potential candidate for upholding potential drops along the magnetic field lines that can explain the acceleration of auroral electrons and ions. A statistical study of the occurrence of these structures is underway, and the structures always

seem to be correlated with the presence of beams of energized, upward flowing ions.

Even if double layers provide a viable mechanism for particle acceleration, other possibilities also exist, such as interaction with resonant periodic plasma waves. Studies are therefore going on to determine the occurrence and properties of lower hybrid waves and of Alfvén waves. Preliminary results indicate that the amplitude of the lower hybrid waves is generally too small for the waves to be of decisive importance for acceleration of auroral electrons. Alfvén waves of sufficiently large amplitude are frequently observed, but the efficiency of the Alfvén waves for particle acceleration depends strongly on their wavelength perpendicular to the magnetic field. This wavelength is impossible to measure directly, but may be estimated by analysis of the measured weak plasma density fluctuations of the waves. Signatures of such fluctuations are seen in the Viking data. An extended analysis of the instrument response to such weak signals is now going on.

Particular examples of coherent Alfvén waves, subject to study, are the Pc1 pulsations in the frequency range 0.2 – 5 Hz, seen in the electric and magnetic field measurements as well as in the plasma density measurements.

A comprehensive study has been undertaken of signatures in the Viking wave data of crossings of field lines mapping to the magnetopause boundary layer and to the cusp. The agreement between actually observed positions of these features and predictions by the Tsyganenko models has been found to be good. It has also been established that corrected geomagnetic coordinates are superior for ordering of high latitude data.

A study has been carried out of the night–side plasma cavities detected by Viking at invariant latitudes above 60° and altitudes of 3,000 – 10,000 km in which auroral kilometric radiation can be generated. The plasma density can here be reduced to well below one particle per cubic centimeter. It is only by a careful analysis of the disturbance caused by photoelectrons emitted from the spacecraft structures that it has been possible, for the first time, to infer such low densities.

An extensive study has also been made of other possible errors in the probe measurements of potential and density variations, and the conclusion is that these are generally small and well understood. A comparison has also been made of the densities inferred from the Langmuir probe theory and the densities measured from the resonance sounder and the lower hybrid wave cutoff. An excellent agreement was found.

Freja. The Uppsala Space Physics Group is responsible (with Bengt Holback as Principal Investigator) for the comprehensive wave experiment on the next Swedish scientific satellite, Freja, to be launched in October 1992. The instrument, that has been manufactured during the last two years, is designed to measure electric, magnetic and density

components of wave fields at frequencies up to 10 kHz, and for one electric field component even up to 4 MHz, using the wave form technique. Simultaneous snapshots of the actual waveforms for several wave components will thus be recorded, with an unsurpassed temporal resolution. The experiment is designed in cooperation with groups in France, Norway, and USA, and groups in Finland, Denmark and Sweden are also involved in the software development.

Cluster. The group also has the main responsibility (with Georg Gustafsson as Principal Investigator) for the Electric Field and Wave experiment of the four Cluster spacecraft, to be launched in 1995. Cluster, together with SOHO, constitute the first cornerstone project within the ESA long term program Horizon 2000. The experiment involves a large team from 16 scientific groups from Europe and the USA. Measurements of electric field or plasma density variations will be performed using four probes on long wire booms on each spacecraft. The experiment has now been designed, and manufacturing and testing of all the units is underway. The Uppsala group is also heavily involved in the planning and coordination of the extensive data handling required for the Cluster project.

Cassini. The Space Physics Group is involved (with Co–investigators) on the Radio and Plasma Wave investigation for the Cassini mission within the NASA program (with prof. D. Gurnett of the University of Iowa as Principal Investigator). Cassini is a joint NASA and ESA venture to study the Saturnian system with its moons, rings and magnetosphere. The Uppsala group will provide hardware and software for a spherical Langmuir probe and electronics to measure the plasma density and temperature, and for using the long cylindrical antennas for two point density variation measurements. Preliminary design work is now going on for the experiment. Currently the spacecraft is planned to be launched in 1997 and would then reach Saturn in 2004.

Impact. Impact is a proposed follow up of the Viking and Freja projects to study the ionosphere–magnetosphere interaction and particle acceleration processes. The project is proposed to be carried out in a multinational collaborative effort, with a substantial involvement from the Swedish side, but also from several other countries in Europe. As the proposed two–spacecraft mission should be able to address a number of questions raised by the Viking results there is very strong interest from the Space Physics Group to participate in the mission with a comprehensive wave experiment.

Plans for 1992 and beyond

Future efforts will include:

- Operation of the Freja wave experiment and analysis of data.
- Continued analysis of data from the Viking experiment.
- Tests of the hardware and continued software development for the Cluster electric field and wave experiment. From 1996 operation of the experiment and data analysis.
- Design, manufacture, and tests of the Langmuir probe part of the Radio and Plasma Wave experiment for the Cassini mission, from 1997 preliminary operation of the instrument, and from 2004 measurements in the Saturnian magnetosphere and the ionosphere of the moon Titan.
- Participation in preparations for the Impact mission, and development of an experiment proposal for detailed studies of plasma wave phenomena and particle acceleration processes.

Space Physics Group, Department of Plasma Physics of the Alfvén Laboratory, Royal Institute of Technology

Address: Department of Plasma Physics of the Alfvén Laboratory, Royal Institute of Technology, S-100 44 Stockholm, Sweden

Professor Carl-Gunne Fälthammar
Prof Göran Marklund

Research programme

The research programme of the Space Physics group is mainly centered on the plasma physics of the ionosphere and magnetosphere, with special emphasis on the role of electric fields. The dominating effort is the measurement of electric fields and electron density by means of electric double probes aboard satellites and rockets.

The large scale electrodynamics of the high latitude ionosphere is investigated using data from Viking and other satellites, as well as ground based observations, and applying a quantitative modelling technique developed by the group. The conditions for existence and the processes of formation of electric double layers and other kinds of magnetic-field-aligned electric fields are studied.

The space research is carried out in close contact with laboratory plasma experiments. This is highly beneficial to progress in both fields.

Acitivities during 1990 and 1991

Satellite experiments

Analysis of data from earlier satellites

GEOS 1, GEOS 2 and ISEE-1, where members of the group were Co-Investigators for the electric field experiment yielded rich datasets, which continue to be analyzed and produce scientific results.

Viking

The Royal Institute group had PI responsibility (Lars Block and later Göran Marklund) for the electric field experiment on the first Swedish satellite, Viking. During the last two years Viking data have been the basis for a large number of publications, including one doctor's thesis, and the analysis continues.

Freja

A major task in the 1990-91 time frame has been the building and testing of the electric field measuring instrument on the second Swedish scientific satellite, Freja (PI Göran Marklund). The flight hardware has been delivered on time in February 1991, and tests are continuing in preparation for an October 1992 launch.

Cluster

The Royal Institute Group is Co-Investigator on the electric field and wave experiment (EFW) on the international satellite project Cluster. Furthermore, the Royal Institute Group will host the *Scandinavian Data Center of the Cluster Science Data System*.

Rocket experiments

These are used for studies, in the auroral zone and dayside cleft regions, of the electric field and plasma parameters by means of a double probe technique. This was originally developed for dc measurements, but operating in special modes the probes are also used for intermittent determinations of electron temperature and density along the flight path.

Future plans

The near future efforts will include the following tasks.

Satellite programme

- Analysis will continue of data from the ISEE-I, GEOS and Viking satellites.
- Launch of the Freja Satellite in the autumn of 1992 and scientific analysis of the data.
- Testing of the electric field experiment for the Cluster satellites.
- Establishing of the Scandinavian Data Center of the Cluster Science Data System.
- Development of a new generation of electric field instruments with better time resolution and larger dynamic range, suited for future satellite experiments.
- Planning for participation in future satellite projects.

- Analysis of data from earlier rocket flights in particular the CRIT (Critical Velocity) rocket project.
- Participation in the international rocket project "Auroral Turbulence", scheduled for launch in early 1993.
- Development of a rocket version of the new generation of electric field instruments.

Section for Atmospheric Physics, Department of Meteorology, Stockholm University

Address : Department of Meteorology, Stockholm University, Arrhenius Laboratory, S-106 91 Stockholm, Sweden.

Prof Georg Witt
Dr Donal P Murtagh
Dr Jacek Stegman

Programme

The research programme in Atmospheric Physics at the Department of Meteorology is concentrated on the physics and environmental impact of minor constituents with emphasis on the structure and composition of the Middle Atmosphere mainly between the altitudes of 20 to 140 km. Experimental studies are conducted mainly by means of optical-spectroscopical measuring techniques from both ground-based and rocket-borne platforms in close coordination with related studies by other techniques. Recently, the activities have been extended to satellite experiments. The main directions of the current research are

- The photochemistry and variability of minor constituents, specifically atomic oxygen and ozone, nitric oxide and odd hydrogen components, and the production of related airglow and auroral emission features with emphasis on conditions at high geographic and geomagnetic latitudes.
- The structure of the mesopause region in high latitudes with special emphasis on small-scale dynamics such as wave motions and turbulence as well as the physical processes responsible for the formation of noctilucent and polar-mesospheric clouds.
- The spectroscopy of the airglow and the aurora, especially the clarification of the excitation mechanisms.
- The polar ozone problem and anthropogenic effects on the ozone budget.

Activities during 1990 and 1991

Sounding rocket programme

The section for Atmospheric Physics on a continuous basis collaborates with a range of institutions in different countries, within the frame of coordinated rocket- and ground-based field experiments as well as in the development of rocket instrumentation. The cooperative rocket campaign AURORA 90 (Esrange, February 1990) was a joint venture involving the Laboratory for Aeronomy and Space Science (LASP) of the Colorado University, Boulder, CO, USA and the Technical University of Graz, Austria and the Institute for Space Physics in Sweden. The

AURORA-90 study was coordinated with the global dynamic study DYANA, specifically with several rounds of the German spectroscopic rocket payload SISSI where the cooperation was extended to the Gesamthochschule Wuppertal, Germany and the Utah State University, USA. A further pair of SISSI rockets were launched during the Summer of 1990. These rockets were equipped with a cryogenically cooled IR spectrometer from the University of Wuppertal,Germany, a resonance-fluorescenc oxygen atom probe, an NO resonance scattering photometer and a set of plasma probes from the Utah State University (USU). The USU instruments were complemented by the newly-developed miniature scattered-light photometer SLIPS from this Institute. The first of the two launchings took place in the presence of a photographically documented NLC display.

Another international engagement is the polar summertime mesopause study **NLC-91/DECIMALS**. This rocket-radar campaign took place during the Summer 1991 from Esrange and from the Russian Arctic launch site Heiss Island (80°N). The **NLC-91/DECIMALS** venture involved scientific groups from Austria, Germany, Norway, Russia, Switzerland and USA. The radar study used the EISCAT VHF/UHF systems in Tromsö by a pool of participants from Norway, Finland, the Institute for Space Physics in Kiruna and this group. The intermittent EISCAT soundings were complemented by the continuously operating 50 MHz Cornell University CUPRI radar which was set up on Esrange. Within the frame of NLC-91 Swedish instruments were launched on board of Russian rockets from the Arctic launch site on Heiss Island (80°). The three successful salvoes of the NLC-91 experiment have yielded a substantial amount of new information part of which is to be presented at the 1992 COSPAR symposium. It is worth mentioning that the conclusion from an earlier radar study regarding the non-existence of a direct one-to-one correlation between the radar echoes and noctilucent clouds has been confirmed. The Heiss Is. experiment was the first attempt to investigate the aerosol layer near the mesopause within the Polar Cap. Noctilucent clouds were detected optically at the height of, 80–81 km on one of three different nights.

Atomic oxygen

The direct measurement of atomic species by the RF technique offers a range of experimental problems such as the radiative transfer of the resonance radiation both within the light source and in the medium under study, the adverse effects of the rocket bow shock and contamination of the measuring volume by outgassing. Earlier studies of this kind within the rocket projects **CAMP, MAP/WINE** and **EPSILON** have provided the necessary experience for the construction of a novel rocket-borne RF probe **ATOMIC**, flown successfully for the first time in the winter campaign **AURORA-90** (February 1990) from Esrange. The

ATOMIC probe consists of two separate units. The top unit has been given a specific aerodynamic design so as to minimise the effects from the bow shock. Resonance radiation is emitted in a direction perpendicular to the rocket axis so as to avoid the Doppler shift of the supersonic motion. Part of the light beam is intercepted by a pair of photodiodes on two arms of different lengths. This set-up provides a differential absorption measurement which reduces the sensitivity of the measurement to shock effects. The resonantly backscattered light is also recorded. The same set-up is used to measure the scattered light from a krypton and an argon resonance lamp which is used to derive the density profile of this noble gases as a measure of the atmospheric density. The active probe is complemented by a pair of airglow photometers measuring a selected pair of emission components such as the oxygen green line and the (0–0) Atmospheric band of O_2, alternatively or an auroral O-atom line.

The second unit is placed in a section further back in the payload and restricted to a resonance backscatter experiment for atomic oxygen and another atom such as hydrogen or krypton, so far without the facility for absorption measurement. The original purpose of this additional O-atom experiment was to explore the aerodynamics and to obtain a comparison between this restricted experiment and the more complete top probe. The arrangement of the lower unit of **ATOMIC** is intended for future applications where O-atom measurements are needed but where the forward section of the rocket payload is not available.

Nitric oxide

In contrast to atomic oxygen and carbon monoxide which are almost exclusively produced by solar UV photodissociation in, nitric oxide has a powerful source in the polar aurora. The increase in the NO abundance following major geomagnetic events has been well documented and the production mechanism is fairly well known. However, there remain some questions concerning the variability of NO, especially with respect to the influence of local transport processes on the auroral NO chemistry. Another rocket study within the above mentioned winter campaign **AURORA-90** addresses this particular problem. The nitric oxide molecule is detected by its resonance fluorescence that dominates the near-UV spectrum of the Earth's dayglow. Guided by the experience from earlier rocket measurements of the resonance fluorescence in the NO g-system a new spectroscopic rocket sonde **ANODE** has been designed. This instrument combination is equipped with two different spectroscopic devices, MISU-s concave-grating UV polychromator which measures the NO emission with the aid of a differential-absorption technique, and an imaging UV spectrograph from Colorado University. The ANODE probe was successfully launched in February 1990 and the interpretation of the results is in progress.

The Odin Satellite Project

Since the beginning of 1990 the atmospheric physics group has been involved in the planning of a new Swedish satellite project with the name **Odin**. This satellite is a joint astronomy/atmospheric science mission which utilises sub-mm wave spectroscopy to measure the abundances of various species in space and in the Earth's stratosphere and mesosphere. The involment at MISU is on the atmospheric science side. A feasibility study was carried out in 1990 after which the Swedish national space board commisioned a phase-A study that was completed in October 1991.

The aeronomy part of the Odin mission will address scientific problem areas in the stratosphere and mesosphere by making measurements of various trace species. The scientific goals can be summarised as follows

- Stratospheric ozone science: To elucidate the geographical extent of and mechanisms responsible for ozone depletion in the "ozone hole" region and to study dilution effects and possible heterogeneous chemistry even outside of the polar regions due to sulphate aerosols.
- Mesospheric ozone science: To establish the relative role of odd hydrogen chemistry and the effects of ordered and turbulent transport and corpuscular radiation.
- Summer mesosphere science: To establish the variability of mesospheric water vapour including as assessment of the required fluxes for aerosol formation in the polar mesosphere.
- Coupling of atmospheric regions: To study some of the mechanisms that provide coupling between the upper and lower atmosphere, eg downward transport of aurorally enhanced NO with its effects on ozone photochemistry and the vertical exchange of minor species such as odd oxygen, CO and H_2O.

The Odin sub-mm receiver enables detection of species such as ClO and

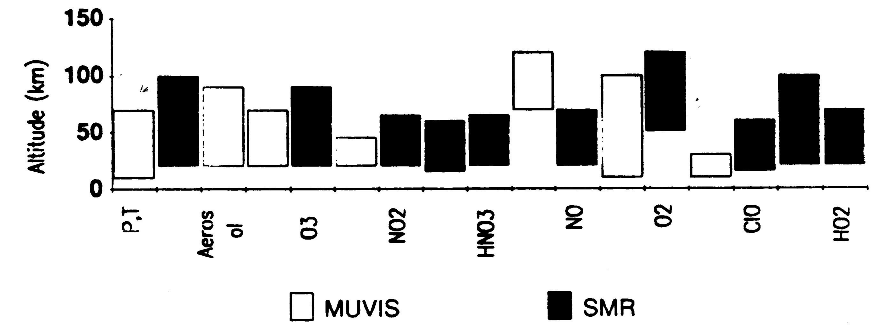

Fig 1. Estimated species and altitude coverage for Odin for the optical spectrometer (MUVIS) and the sub-mm receiver (SMR).

H_2O with high sensitivity because these molecules have some of their strongest rotational lines in the region 500 – 600 GHz. The fact that these emissions are of thermal origin permits measurements even in the night-time atmosphere which is particularly important for studies in the polar night. The two (of 4) frequency bands that are of greatest interest for the aeronomy mission are centred around 557 GHz and 575 GHz with a width of $\pm$ 1%. Two 1000-channel 1 GHz bandwidth spectrometers may be placed in these bands and together they allow simultaneous measurements of for example ClO, CO and H_2O to be made. Other species that are detectable are O_3, NO, N_2O, NO_2, H_2O_2, HO_2 as well as various isotopic forms of O_3. About 40 limb scans will be executed every orbit. With the 1.1 m antenna the vertical resolution on the limb will be about 2.5 km although this will be somewhat worsened by radiative transfer effects and attitude uncertainties.

As a necessary complement to the sub-mm measurements Odin will also contain the uv-visible-IR spectrometer package MUVIS which will permit measurements of O_3 by more traditional methods, NO_2 by differential optical absorption spectroscopy, aerosols both in the stratosphere and mesosphere, thermospheric NO from its resonance fluoresence as well as species such as BrO and OClO under special conditions. Pressure and temperature may also be determined from the Rayleigh scattering profile. The instrument will operate in the backscatter limb viewing mode and have a vertical resolution of about 1 km.

A preliminary estimate of the species and altitude coverage expected for Odin is given in figure 1 although profiles for some of the species will not be obtained for every limb scan but only as zonal or temporal averages.

Plans for the nearest future

The rich harvest of experimental data from the recent years' rocket and ground-based ventures has already contributed to a better understanding of the physical structure of the transition region between the thermosphere and the mesosphere. However, many of the questions posed remain unanswered. Also, the improved performance of the measuring devices, not the least with respect to time and altitude resolution, led to the discovery of scores of new problems. Many of these problems, notably those involving the microphysics of ion clusters and solid particles, require continued theoretical analysis and laboratory studies. One example is the charging of aerosol in the sunlit, weakly ionised plasma near the mesopause, another is the process of ion-induced nucleation. As to the detection of solid "dust" particles which escape detection by optical means, a measuring technique has still to be developed.

Another field where further research is motivated concerns the "climatology" of minor gas constituents in the middle atmosphere. Optical

mesaurements remain the most powerful tool for remote sensing of the chemical changes in the 80–120 km region. However, in order to obtain a comprehensive picture of transport effects, different techniques must be combined. Thus, the ongoing continuous survey of oxygen-related airglow which up to now has been restricted to the visible-near UV region will be complemented by measurements in the near-IR region. The IR measurements concern the OH and $O_2\ {}^1\Delta_g$ chemiluminescence from high altitudes as well as the thermal emission from stratospheric species important to the chemistry of polar ozone. Another improvement is the coordination of the optical measurements with ozone, and CO measurements by means of microwave radiometry. These studies will be conducted in cooperation with Utah State University and the Onsala Space Observatory in Sweden.

Concerning rocket experiments, two major efforts are currently planned. The first of these, **DECIMALS-93**, is a continuation and follow-up of **NLC 91**. The campaign which is proposed to take place during the Summer 1993 from Esrange concentrates on problems directly related to the microphysics of aerosol layers and comprises two rounds of the improved **DECIMALS** payloads. The campaign is to be coordinated with a similar Norwegian-German venture from Andöya, radar soundings using EISCAT and extended ground-based studies

The second rocket study,concentrates on radiation exchange processes in the wintertime 80–140 km region with emphasis on the deviations from Local Thermodynamic Equilibrium conditions. The detailed scientific programme for this campaign, with the provisional name **NLTE**, is currently being formulated in cooperation with the Gesamthochschule Wuppertal and Utah State University.

Airborne in-situ measurements of water vapour by means of optical hygrometers is one of the fields were future experiments are envisaged. The hygrometric measurements are planned to be carried out in cooperation with the Central Aerological Observatory in Moscow. Part of the H_2O experiment is an extension into the upper troposphere and lower stratosphere of an ongoing study of the chemistry of clouds. Another development is dedicated to the detection of water vapour above the ceiling of stratospheric balloons.

Lund Observatory, University of Lund

Address: Lund Observatory, P.O. Box 43, S-221 00 Lund, Sweden

Dr Bertil Anders Lindblad
Prof Dainis Dravins
Dr Lennart Lindegren
Prof Arne Ardeberg

At the IAU meteor data center in Lund some 60 000 photographic and radio orbits have been archived. The data is available on diskettes (photographic data) and magnetic tape (radio data). In collaboration with the Electronics Laboratories, University of Kent at Canterbury and other groups we are participating in a dust experiment on the extended GIOTTO mission to comet Grigg-Skjellerup. A study of the meteor stream associated with Grigg-Skjellerup has been carried out for comparison with the space results. Together with the Max-Planck-Institut für Kernphysik in Heidelberg our group is participating in a dust experiment onboard the GALILEO spacecraft. Initial results from the Earth-Venus-Earth trajectory have been presented.

Basic solar-terrestrial physics studies have been carried out. Different plasma structures, such as coronal mass ejections, coronal holes, the heliosperic current sheet, and their interaction with the earth's magnetosphere, have been studied.

Neural networks have been applied to solar-terrestrial physics both for prediction purposes and for the recognizing of patterns and categories in solar-terrestrial data. The trained neural network successfully models the non-linear energy coupling between the solar plasma and the earth's magnetosphere. Solar and geophysical data from space and worldwide groundbased observations are daily accessed via computer networks. These data serve as input data for the neural networks. Solar-terrestrial databases are also under development. A third catalogue of high speed plasma streams in the solar wind based on space probe measurements in the period 1978-82 has been published. Further catalogue work is planned.

Space observations of stellar activity have been analyzed at the Lund Observatory. The distant future of solar-type activity is studied through a detailed comparison of the present Sun (G2 V) with the very old star *Beta Hydri* (G2 IV). This star is very similar to the Sun, except for age ($\simeq$ 9.5 10^9 y). Magnetically related chromospheric activity decreases with age, and in such old stars one might find the lowest possible level of stellar activity. The chromospheric emission is also significantly weaker than in the Sun. The Mg II emission variability was monitored from the *IUE* satellite during about 12 years, recording some 100 high-resolution line profiles. Accurate spectrophotometry is assured by *IUE* image processing techniques recently developed at the Lund Observatory, and

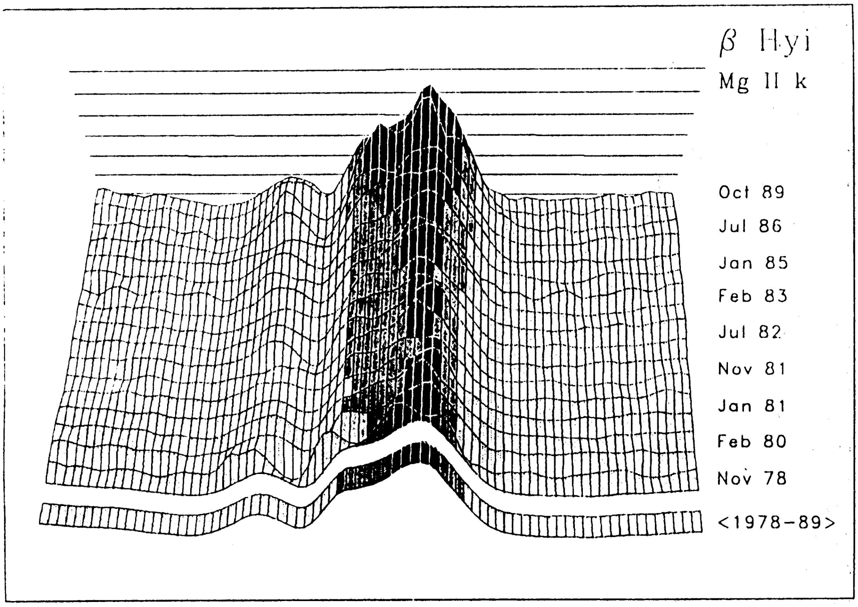

Fig 1. Long-term variability of Mg II *k* emission profiles in *β Hyi*, as observed from IUE. Data from 17 epochs build up a surface of intensity versus wavelength. The projection illustrates the slight decrease of activity for a few years after 1978, followed by the build-up to maximum in 1986. The data strip in front is the average profile. The changes over the years are remarkably gradual, and suggest an activity cycle with a period of 15–18 years.

since adopted by the *IUE* project in the reprocessing for its final data archive. The emission variations are small ($\leq$ 30% in Mg II *h & k*), and are characterized by smooth and systematic changes from year to year, suggesting continuous changes in the chromospheric structure, rather than the sudden emergence of active regions. These 12 years embrace both an activity minimum and a maximum, consistent with an activity cycle somewhat longer ($\simeq$ 15–18 years) than the solar one. This is the first activity cycle in an ordinary star detected from space and, assuming the Ca II emission variation (previously studied in many stars from the ground) to follow that of Mg II, is also the lowest-amplitude activity cycle ever detected.

The far-UV emission lines from the transition zone of *β Hyi* are among the faintest so far seen in any solar-type star. The coronal soft X-ray spectrum was measured through different filters on *EXOSAT*, and compared to simulated X-ray observations of the Sun seen as a star. The flux from ß *Hyi* is weaker than that from the solar corona, and has a different spectrum. An analysis based on an isothermal plasma emissivity model yields *either* $\simeq 5\ 10^5$ or $4\ 10^6$ K for its coronal temperature (compared to an equivalent solar value of $3\ 10^6$ K). It is suggested that the 'cool' coronal solution for *β Hyi* could be an intermediate evolutionary step to losing

an observable corona altogether, as is the case in more evolved cool giants. If the 'cool' coronal solution is appropriate, it could further imply that a thermally driven stellar wind can no longer be supported, removing the mechanism for further rotational braking of the star through a magnetic stellar wind.

The Lund Observatory participates in a large international collaboration for reducing and analyzing the scientific data generated by the ESA space astrometry satellite Hipparcos. Within the so-called Northern Data Analysis Consortium (a collaboration with British and Danish institutes) we are responsible for the last stages of the astrometric reductions including the special treatment of double and multiple stars. Most of the effort during 1990 and 1991 has been devoted to very detailed and extensive testing of all aspects of the reduction software. For validation purposes a selection of satellite data from the first year of operation (since December 1991) has been analyzed, already giving positions and parallaxes for thousands of stars with accuracies in the 3 to 10 milli-arcsec range. These results are described in a series of papers to appear in Astronomy & Astrophysics. The complete reduction of the whole first year of data, scheduled for March 1992, is expected to give an accuracy of 4 milli-arcsec for the majority of the 120,000 stars in the observing programme. With the satellite already well into its third year of operation, the chances are now very good that we will eventually achieve the planned 2 milli-arcsec overall accuracy.

Members of the research groups at the Lund Observatory participate in a number of scientific programmes for the Hipparcos mission. These include the determination of cluster membership of Cepheids, physical parameters and kinematics of late-type stars, radial velocities determined from astrometric data, and determination of a dynamical reference frame from observations of minor planets.

Preparing for the data to be received from the Hubble Space Telescope on chemical evolution and history of star formation in the LMC, observations with groundbased telescopes have been made and analyzed. From CCD imaging of crowded stellar fields, a software package for reduction and analysis of HST data has been developed. This reduction package is presently studied and improved through matching to simulations of HST FOC exposures. An investigation of in-orbit flat fields has been made to verify the performance of the FOC camera.

Planned proposals for the Hubble Space Telescope include: 1) A survey of the M33 disk and its open cluster system (together with scientists from USA , Germany, Australia and India). The Wide Field Camera (WFC) will be used with U, V and I filters to investigate clusters at different radial distances in M33. 2) Unstable accretion flow onto a magnetic white dwarf. The Faint Objective Spectrograph (FOS) will be used to study the wavelength dependence in the UV of oscillations previously observed in the visual. For the above projects it is planned that the data analysis will take place in Lund.

Stockholm Observatory, Stockholm University

Address: Stockholm Observatory, S-133 36 Saltsjöbaden, Sweden

Dr Lennart Nordh
Dr Göran Olofsson
Dr Gösta Gahm

Activities during 1990 and 1991

The major part of the space-related work has been devoted to three infrared/submm space experiments. Work has also been conducted in connection with preparations of HST proposals.

Balloon experiments

With support from the Swedish National Space Board, the Swedish Space Corporation and ESTEC the Stockholm Observatory is running a balloon experiment aiming at spectroscopic studies of the interstellar medium at far infrared and submm wavelengths. Two flights, one in 1990 and one in 1991, have been conducted from Esrange (in the northern part of Sweden) in order to observe the C^+[158μm] emission line from galactic molecular clouds. The stabilized balloon gondola was in both cases equipped with a 30 cm telescope and a LHe cooled, scanning Fabry-Perot spectrometer providing a FOV of 11 arc minutes and a spectral resolution of ≈ 800. Data obtained for several objects are presently being analysed.

Satellite experiments

The Stockholm group is involved in the ISO experiment as Co-Investigator of the international group that is responsible for the infrared camera. During the years 1990 and 1991 preparations for the central program have been made.

Since mid 1990 the Stockholm Observatory has taken part in a study of a new Swedish satellite project (Odin) aiming at spectroscopic observations in the frequency range 400 – 600 GHz using tunable radio receivers employing cooled Schottky diode mixers. The adopted size of the telescope is 1.1 m. Discussions with potential international collaboarators are presently taking place. The launch is planned for 1996 and the projected life time of the satellite is $\geqslant 2$ years.

The HST proposals concern studies of the circumstellar regions associated with T Tauri stars and of the morphology of Herbig-Haro objects.

Future plans

All the projects mentioned above will continue. The most important change will concern the balloon experiment PIROG, which in the future will be used for observations of interstellar water vapour emission at 557 GHz using a radio receiver developed by ESTEC. To obtain a reasonably small beam on the sky ($\approx$ 4 arc minutes) the gondola is presently being equipped with a 60 cm telescope. The first launch with the new experiment will take place from Air sur l'Adour in France in the spring of 1993.

Planetary System Group, Astronomical Observatory, Uppsala University

Address: Astronomical Observatory, P.O. Box 515, 751 20 Uppsala, Sweden

Dr Claes-Ingvar Lagerkvist
Dr Hans Rickman

Activities during 1990 and 1991

The *Asteroid Photometric Catalogue,* containing all published lightcurves of asteroids up to and including 1987, has been improved. The Uppsala version of it now specifies the photometric system used, and gives information on whether any correction to the observed time and magnitude has been applied by the observer. It is thus suitable for applications requiring reliable reduced magnitudes and light-time corrected epochs. A further updating of the catalogue has been made and the last updating of the catalogue contains almost 1000 lightcurves of 158 asteroids published during 1988–1990.

An observing programme of outer belt asteroids aiming at a better understanding of the properties of these asteroids and of the relationships between these primitive bodies and the comets were carried out. Reflectance spectra of about 20 D-type asteroids and 2 comets have so far been obtained during three observing runs with the WHT on La Palma.

An observing programme of asteroids, by means of polarimetric observations, was started during 1991. The intention is to concentrate the investigation to a few objects of well defined taxonomic types and to gain information on surface properties as well as on rotation, shape and spin axis orientation. The first target was 302 Clarissa (taxonomic type C), presently a candidate for the Cassini mission. Observations in November with the NOT were successful and it was possible to obtain both polarimetric and photometric observations covering a complete rotational cycle.

Analyses of the ground-based observations of 951 Gaspra, recently observed by the spacecraft Galileo, and determinations of pole and shape, necessary for optimal observing at the encounter has been made. Dr Lagerkvist was a member of the science team for the ESA assessment study of "Orbiting Planetary Telescope".

Models for the formation and evolution of dust mantles on short-period comet nuclei were published. According to these, stable mantles form over most of the area within $\sim$ 10 orbital revolutions unless the nucleus is very small or the orbit has too small perihelion distance. Statistics of nongravitational effects were analyzed in relation to the orbital properties including dynamical histories, and support for the above picture of dust mantling was found. Comet P/Machholz was identified as particu-

larly interesting in view of its orbital evolution bringing it periodically very close to the solar surface and its shedding of large amounts of meteoroidal material into Earth-crossing orbits at such occasions.

The origin of the nongravitational effects in the orbital motions of short-period comets was clarified by demonstrating a tight correlation between such effects and the light curve asymmetries of the corresponding comets. This allows improved possibilities to provide search ephemerides for comets of only two observed apparitions or to predict changes in the nongravitational effects from observed changes in the light curves. It also offers a sound approach to physical interpretation of the orbital effects, whereby e.g. the masses of some cometary nuclei can be estimated.

Rickman is a member of the coinvestigator team with special responsibility for pre-encounter modelling and post-encounter analysis.

The possibility of using the proposed Odin satellite heterodyne receivers to detect and measure the 557 GHz ortho-H_2O emission in comets was studied. Five periodic comets were identified as prime targets, having expected outgassing rates $>10^{28}$ molecules per second at favourable observing geometries during 1996–1999.

Future plans

A new updating of the *Asteroid Photometric Catalogue* is in progress and will cover the observations during 1991–1993.

The observations of the outer-belt asteroids are now to be concentrated on the Hilda asteroids. This is a rather isolated, small group of asteroids (53 numbered Hildas), situated in the 3:2 mean motion resonance with Jupiter and with most of their physical properties unknown. The forthcoming spectroscopic observations of almost all Hildas (4 nights on the NTT have been allocated for 1992) will give the necessary data on their surface compositions.

A project for observing asteroids at mm wavelengths has recently started. Except for giving information about the surface layers these observations will be used for the calibrations of the infrared instruments aboard on ISO. The first observations are scheduled for the fall of 1992. The analysis of the ground-based observations of 951 Gaspra will continue as well as the ground-based observations of the various space mission targets.

Model development is foreseen regarding the outgassing flux of periodic comets for interpretation of photometric observations of gas production rates, and the diurnal outgassing pattern for interpretation of nongravitational effects. This will involve the modelling of subsurface crystallization, sublimation and gas release. Observations will be carried out in order to obtain both photometry of cometary nuclei and improved char-

acterization of gas production curves. In combination with orbit determinations incorporating the nongravitational force in a realistic way, this will help to constrain the physical properties of cometary nuclei better than before.

Studies of orbital dynamics of comets will also be carried out in order to link the presently observed short-period comets more reliably to their place of origin, thereby allowing to carry the information about nuclear structure over into cosmogonical implications for the physical processes in certain parts of the solar nebula or presolar cloud. Such a link will of course also be of great value when it comes to interpreting the data obtained by space missions.

Onsala Space Observatory, Department of Radio and Space Science, plus the Millimetre wave group, Chalmers University of Technology

Adresses: Onsala Space Observatory, S-43900 Onsala, Sweden, and Chalmers University of Technology, S-41296 Göteborg, Sweden.

Prof Roy S. Booth (Radio- and Far Infrared Astronomy)
Prof Bernt Rönnäng (Space Geodesy and Geodynamics)
Prof Jan Askne (Remote Sensing)
Prof Erik Kollberg (Microwave and Millimetre Techniques)

This report covers a wide range of space related research including Remote Sensing, Space Geodesy and ground and space based Radio Astronomy. The Millimetre Wave Group, also represented in this report, is a collaboration with a sister institute at CTH, the division of Applied Electron Physics, and reflects our common interest, conducting research into microwave and millimetre devices for use in space missions as well as for ground based radio astronomy.

Onsala Space Observatory is the Swedish National Facility for Radio Astronomy and operates two telescopes at Onsala (a 25.6m decimetre wave telescope and a 20m radome enclosed millimetre-wave antenna) and the Swedish-ESO Submillimetre Telescope (SEST) situated on the ESO observatory site of La Silla in Chile.

Radio and far infrared astronomy in space

The programme of astronomical research at Onsala Space Observatory is strongly influenced by Space projects. These include the ESA projects, FIRST and ISO, as well as the proposed Space VLBI missions. The group is also co-proposers of a Swedish-led mission for a satellite borne submillimetre observatory, Odin, for astrochemistry and aeronomy.

Odin is a proposed Swedish satellite for aeronomy and astrochemistry and will carry a 1m telescope and receivers for submillimetre spectroscopic observations of molecules in the Earth's stratosphere and molecules in interstellar space that are not observeable from the ground because of strong absorption at their emission frequencies. Among the astronomically significant molecules are water and oxygen which have spectral lines at 557 GHz and 487 GHz respectively. The oxygen detection is regarded as very important in astrochemistry and for this reason a separate receiver for the ground state transition (119GHz) is also included.

Space VLBI. For the past decade the Onsala Space Observatory has been part of a strenuous European effort to persuade ESA to place a radio telescope and receivers in Earth orbit for use with the ground VLBI network of telescopes, to extend the baselines and therefore the resolution of the

very long baseline interferometers and also to improve the imaging capability of the networks. The VLBI mission, QUASAT was regarded as too expensive after its phase A study in 1988, and so was dropped. This left the field to the Russian RADIOASTRON mission and the Japanese VSOP mission, both 10m telescopes to be launched in 1994 and 1995 respectively. Radioastron will be boosted into a high apogee orbit (apogee height as large as 100 000 km) while VSOP will have a more modest (imaging) orbit with apogee height 20000 km.

As stated above, the Russian and Japanese space VLBI telescopes are still on target for launch and the observatory is represented in study groups for these missions through Booth. Members of staff have presented papers at two space VLBI symposia, in Japan in 1989 and at the 1990 COSPAR special session on Space VLBI.

Related Ground-based Astronomy

VLBI

The expected resolution of the planned space VLBI projects at centimetre wavelengths can actually be matched with ground-based VLBI at millimetre wavelengths, although the number of detectable sources is limited. Onsala has played a pioneering role in millimetre VLBI observations and the technique is maturing rapidly. Recent transatlantic observations at wavelengths of 7mm and 3mm have resulted in maps of the central regions of some quasars on linear scales of light days. Comparative studies at longer wavelengths will be carried out with space VLBI.

Other studies related to space VLBI are the investigation of the potential of earth-space baselines for studying OH and H_2O masers. The increased resolution will not only be useful in studies of the intrinsic properties of the masers but also as probes of the electron distribution of the interstellar medium through measurements of source broadening by scattering.

Millimetre-wave spectroscopy

The IRAS satellite has produced a vast data base of observations on all types of astronomical objects. Using the Onsala 20m and SEST telescopes we are investigating samples of evolved stars and galaxies with strong IR fluxes.

Evolved stars

A sample of IR stars is being observed in the CO ($J=1-0$) line to investigate the molecular content of their stellar envelopes as a function of IR colour. One of the aims of this work is to provide a data base for further

study and in addition we hope to define an evolutionary sample for study with the forthcoming infrared space observatory, ISO. Many new stellar sources of CO have been detected in this study.

Studies of other evolved stars have also revealed important targets for ISO, especially a group of stars with very thin molecular shells which are thought to undergo episodic mass loss.

IR Galaxies

The IRAS galaxies are also being observed in the CO line and interesting correlations are found between the CO and far IR luminosities. The larger the star-formation rate the stronger the CO line. The integrated CO intensity can be related empirically to the total mass of molecular gas and hence to a measure of star formation efficiency. The most luminous IRAS galaxies have strong CO signals and extremely high star formation efficiencies. Their optical properties suggest that they are the result of mergers between spiral galaxies and the fact that they are relatively strong radio continuum sources suggests that the high mass of molecular gas may be feeding a central black hole, forming a quasar. A recent multi-line CO study of a merging system, NGC 3256, has revealed that the molecular gas near the nucleus unusually warm, (100 – 300K). The inferred high temperature of this neutral material led us to predict a high flux in the 63 micron line of [OI], which has been confirmed by observation.

Atmospheric studies

Radio astronomical spectroscopy may be used to study atmospheric line emission and studies of atmospheric CO have been underway at Onsala for some years. The technique has now been extended to observe the broad atmospheric ozone line near 110 GHz, and regular observations are made. It should be possible to monitor the global motions of atmospheric ozone and CO by combined observations at a number of sites. Of course, since atmospheric gases are widely distributed they do not require narrow pencil beams for their study and so a simple microwave horn antenna can suffice.

Microwave and millimetre techniques

More and more space missions in the field of astronomy and atmospheric science are requiring very low noise systems and it has become imperative to attempt to space qualify devices which are barely state of the art even for ground based laboratory work. The group has been involved for some time in the technical studies for the FIRST and QUASAT missions and for the ESA-Swedish balloon project PIROG.

SIS junctions and mixers

ESA supported contracts have resulted in planar slot-line antenna structures, for use with SIS mixers, which have been successfully tested at 800 GHz, giving very acceptable antenna patterns. In addition, a collaboration with the Radio Research Lab. in Moscow has resulted in the production of niobium SIS junctions of high quality which have resulted in a mixer receiver with a noise temperature as low as 250K, single sideband at a frequency of 350 GHz. This is among the best in the world.

GaAs HEMT transistors and millimetre wave amplifiers

The general area of high frequency, low noise amplifiers has important applications to space. As part of an ESA funded limb sounder study a broad-band HEMT amplifier is developed which operates at 77K, giving a noise temperature of 25K. Finally, with Odin in mind, work on HEMT amplifiers for 119 GHz is going on.

Multiplier diodes for local oscillators

ESA is supporting work on single barrier varactors, i.e. varactors with symmetric capacitance-voltage characteristics constructed from epitaxial GaAs, InGaAs or InAs materials (the barrier material is AlGaAs for GaAs and InGaAs, and AlSb for InAs). The goal is to produce more efficient multipliers, improved by a factor ~10 on present performance, which are tuneable over a broad frequency range.

Digital Spectrometer developments

As part of an ongoing development at the observatory, a digital hybrid spectrometer for the Stockholm/ESA PIROG balloon project is developed. This instrument can operate with bandwidths of 80, 160 or 320 MHz with a resolution varying from 400 to 800 kHz. Such developments have important space applications, since digital technology is proven to be reliable in the space environment.

Space Geodesy and Geodynamics

Space geodesy research is mainly carried out within three main areas, namely (1) Very Long Baseline Interferometry (VLBI), (2) Precise positioning using the Global Positioning System (GPS) and (3) Studies of the radio wave propagation delay in the atmosphere. The Onsala Space Observatory has been selected as a fundamental geodetic reference site in both the IGS (International GPS Geodynamics Service) 1992 campaign and the new international DOSE (Dynamics of the Solid Earth) program coordinated by NASA. Activities during the period 1990–1991 is summarized.

Very Long Baseline interferometry

The VLBI measurements within the framework of the Crustal Dynamics Project (CDP) coordinated by NASA-Goddard Space Flight Center and within the International Radio Interferometric Surveying (IRIS) program. The purpose of the various on-going programs are: (1) to measure the baselines between the tectonic plates and to improve the global VLBI coordinate system, (2) to study the internal stability of the European part of the Euroasian plate. Particularly interesting are the baselines crossing the Alps and the Mediterranean region, and (3) to estimate earth rotation parameters.

Baseline lengths within Europe are now measured with a repeatability (internal consistency) of a few mm on a routine basis. Reports documenting the results obtained from the VLBI data acquired by the Crustal Dynamics Project are available from the CDP Data Information System (CDP-DIS). Geodetic parameters estimated from VLBI data can also be found in the Annual Report of the International Earth Rotation Service (IERS) published by Observatoire de Paris.

Precise positioning using GPS

More than ten years of geo-VLBI measurements at the Onsala Space Observatory have implied accurate geodetic coordinates based on the extragalactic reference system. In order to transfer the accuracy of VLBI to GPS a tracking station for GPS satellites is in continuous operation at the observatory since 1987 as part of the international CIGNET network. With the GPS receiver at a site where well defined VLBI coordinates already exist it is possible not only to improve the accuracy of the orbital parameters of the GPS satellites, but also to connect the terrestrial and VLBI reference frames. The H-maser frequency standard, the weather station, and the water vapour radiometer used in the VLBI research are also essential for the tracking station.

The accuracy of the VLBI technique is continuously improved and measurements between Onsala and VLBI stations on the east coast of the U.S. show internal consistency (repeatability) in the sub-cm range. It is therefore of great importance to try to detect any local or regional tectonic deformation that could influence the results of the global geodetic experiments. In order to separate possible local and regional movements from the VLBI data a GPS network tied to the VLBI antenna has been established. Preliminary data analysis of dual frequency measurements shows a repeatability of about 0.5 ppm over baseline lengths up to 60 km.

Studies of accurate estimations of the correction for tropospheric delays and in particular the wet component of these delays are important. Of particular interest is the water vapour content of the atmosphere over distances of hundreds of kilometers, its dependence on weather and surface meteorology. The technique for correction of atmospheric delay for GPS measurements is almost identical with the VLBI application. The

difference being the need for estimated wet delays in many directions on the sky at the same time.

Atmospheric Radio Wave Propagation Delay

Microwave radiometry has been used to study the propagation delays due to atmospheric water vapor. Approximately 500 days of radiometer data have been used to characterize fluctuations in atmospheric water vapor. It was found that for the Onsala site (in the Swedish west coast climate) about 80% of the large changes (>2.3 cm/hour) in the wet delay correspond to a passage of a weather front (Elgered). This is not necessarily true for other sites in different climates, *e.g.*, close to the equator.

The Remote Sensing Group

The Remote Sensing Group is working in the field of microwave remote sensing with applications in sea ice, forestry, geoid undulations, oil pollution and ozone layer depletion. The program is strongly associated with the European remote sensing satellite ERS-1 and satellites with microwave sensors such as polarimetric synthetic aperture radars, submillimeter microwave radiometers, etc. The main program is directed toward technical and applied aspects of synthetic aperture radars and radar altimeters including system aspects. An important part of the activities is directed toward a system for near real time information to icebreakers for optimal route information based on temporal sequences of satellite SAR images.

Projects concerning remote sensing of sea ice

The major achievement during 1991 was the Arctic-91 expedition and the related ERS-1 SAR image reception. Arctic-91 was an expedition to the North Pole between 1 August and 14 October 1991. The remote sensing and sea ice program onboard the icebreaker Oden was aimed at calibration and validation of the synthetic aperture radar on the European ERS-1 satellite. The coverage of the ERS-1 SAR is limited to below N 84.6° and the field work thus concentrated on this area. However, a lot of data were also collected further north to obtain general statistics of ice characteristics. A total of 22 field stations were completed during the expedition, of which 7 were within the ERS-1 SAR swath. The main highlights of the programme were:

- First ERS-1 SAR calibration and validation project over sea ice.
- First extensive data collection of cm-scale surface roughness of Arctic ice.
- *In situ* data were collected for nilas, young, first-, second-, and multi-year ice during summer and freeze-up conditions.

- Frequent occurrence of saline 'frost flowers' on the new and young ice during freeze up. These features have a great impact on the radar image since they are very 'rough' to a cm-wavelength radar.
- Four satellite SAR subimages transferred to Oden using HF amateur radio equipment. They were used for navigating Oden to interesting ice floes and to assess the quality of the ERS-1 SAR images.

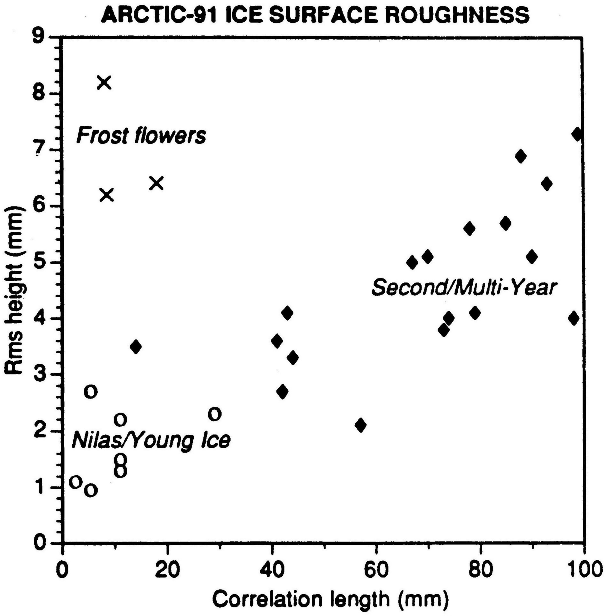

Fig 1. Measurements of the ice roughness in the Arctic along the route of Oden.

Field measurements at the stations included parameters relevant for the radar backscattering of level sea ice, i.e. cm-scale surface roughness, ice physics (temperature, salinity, density, air voids), and snow cover parameters (wetness, density, and depth). A laser-based surface profiler was used to measure surface roughness. The vertical measurement range was 62 mm, and a 1 or 5 metre long height profile was measured with a sample spacing of 0.5 mm. Different versions of the profiler have been used during earlier field experiments in the Baltic Sea (BEPERS-88) and in the Arctic (Beaufort Sea Ice -1, 1990). A total of 400 surface height profiles were acquired. Measurements were performed during 16 stations at 36 different sites. The profiled surface types include: new, young, first-year and multi-year ice, snow and frostflowers. The rms height and correlation length have been computed for the measured surfaces and the results for the ice roughness are plotted in Figure 1. Most of the correlation functions have an exponential shape. A snow fork was used to measure vertical profiles of snow density and wetness. The ice physics measurements included vertical temperature, density and salinity profiles. Ice cores with a diameter of 106 mm were taken and analysed.

Two large trihedral corner reflectors were manufactured with a side length of 1.7 m. The reflectors have a radar cross section of $1.1x10^4$ m^2 at 5.3 GHz.

Helicopter sensor data were acquired for a total of 23 hours during 16 days. The helicopter sensor package consisted of a radar scatterometer, a video camera, a laser profiler and a Hasselblad camera. A similar ship-mounted sensor package acquired data both at station and during steaming.

The collected data will be used to improve radar image interpretation and radar scattering models of Arctic sea ice. Key scientific questions in relation to radar image interstation and air-sea-ice interaction modeling are: How does surface melt conditions effect the radar image? What ice types can be separated in the radar images? Can new ice and open water be separated in the radar images? Can melt ponds be detected in summer radar images? What is the effect of saline 'frost flowers' which often cover new and young ice? An FD ERS-1 SAR image acquired on 4 October is illustrated in Figure 2.

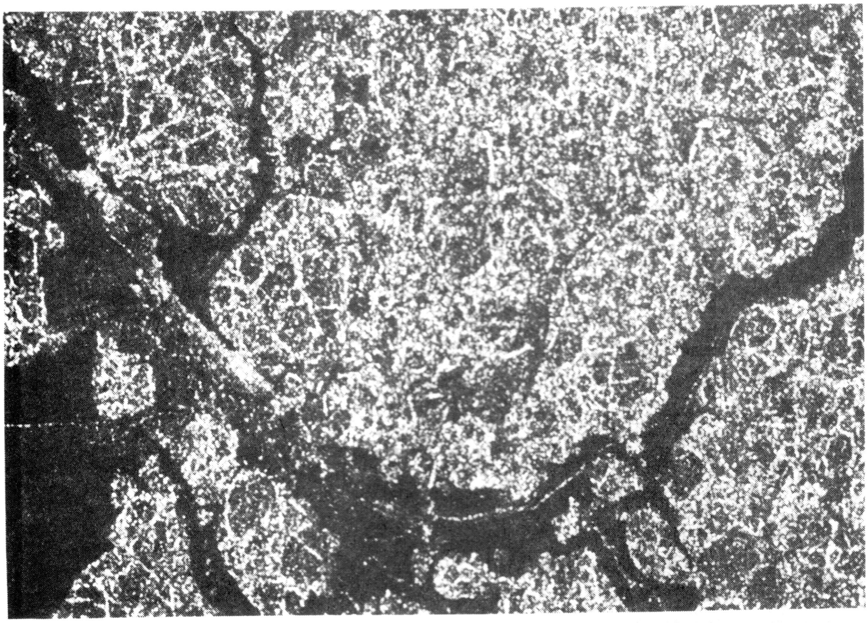

Fig 2. ERS-1 SAR image from the Arctic area (N82 E14) from 4 October 1991. The air temperature is -17°C. The ice is mainly multi year ice.

Projects concerning remote sensing of forestry

Data acquired from the Flevoland test area during the MAESTRO-1 campaign has been used to establish relations between forest characteristics and the radar signal.

In more than 100 stands of mainly poplar, ash, pine and spruce, ground data collection was performed in collaboration with Swedish University of Agricultural Science, Umeå and University of Wageningen, Holland. The basal areas, mean stand heights and trunk diameters were measured. At the longer wavelengths, a relation between the bole volumes and the radar cross sections was found. The polarization responses and the HH-VV phase differences indicate that double bounce trunk-ground scattering dominates at these wavelengths. This relation is currently being verified by theoretical modelling work.

Satellite texts using ERS-1 and JERS-1 are planned for 1992.

Projects concerning remote sensing of surface topography

Satellite radar altimeter data may be used to determine undulations of the sea, caused by gravity anomalies. Compared to traditional measurements, this application of remote sensing provides good possibilities to map the Earth's gravity field in ocean regions, and may in its extension be used for oil- and gas prospecting.

The activities have focused on the possibilities of improving the resolution of spatial wavelengths, as describing the sea surface topography (the small scale geoid) along a satellite ground track. The altimeter measurements are normally presented in 1.0 s averages, giving data for each 7.0 km. The use of existing (but implicit) 0.1 s-averages has shown us that it is possible to recall some of the signal content, that originally were lost in the standard averaging procedure made by the data distributor.

For Geosat, there exist data with a 17 day repeatability, giving up to 64 repeat passages for the entire mission. By averaging repeated measurements, the random noise has been reduced. Using spectral density calculations, the resolution of spatial wavelengths has been determined to be near 20 km along track. This may be compared to the resolution capability of single altimeter profiles, which has been determined to be approximately 35 km. Features (i.e. undulations) with a size down to half the resolution limit in terms of wavelengths, may be detected.

It was shown for Geos-3 that the minimum cross-over error is obtained when an applied post-filter has a cutoff at 25 km. The obtained error of 4.5 cm (rms), may be compared to the approximate error of 10 cm (rms) for nonprocessed (single) Geos-3 tracks.

The influence of atmospheric water vapour on altimetric measurements in a tropical test area have been studied using Seasat data and FNOC-data. It was concluded that realtime measurements of the water vapour is the only accurate way to determine the amount of water vapour. If altimeter data are used unadjusted, there might occur errors of the order of 50 km (spatial wavelengths) and 50 cm (sea surface amplitude), respectively.

Interferometric SAR is a new technique which can be used to generate high resolution topographic maps over land and perhaps ice areas. It enables the correction of radar artifacts such as foreshortening and simplifies the coregistration of diverse images. A program to simulate interferometric SAR measurements has been developed and applied to an area represented by a digital terrain model. The optimal baseline was found to be about 200 m which provided an elevation error of about 6 m (rms).

Projects concerning remote sensing of ozone

In collaboration with the groups at Onsala Space Observatory some work has been going on testing the Chahine method for inversion of ozone observations. The sensitivity for variations in the temperature profile, the number of heights included etc have been evaluated. The study concludes that approximately five to six heights can be used and that it is important to have a good temperature profile.

Planned activities

The main activities during 1992 and onwards will be the analysis of the Arctic-91 observations and continuation of the ERS-1 program concerning ice and ship routing in the Baltic. A major theme during 1992 for all the various projects will be the inclusion of ERS-1 data and data from other satellites.

Manne Siegbahn Institute, Stockholm

Address: Manne Siegbahn Institute, Frescativägen 24,
S-104 05 Stockholm.

Prof Per Carlson

Antiprotons in the cosmic rays

An experiment CAPRICE (Cosmic AntiProton Ring Imaging Cherenkov Experiment) to measure the energy spectrum of antiprotons in the cosmic rays has been accepted by NASA to be flown in their Balloon programme. The project is a collaboration with Strasbourg and the Ballon Borne Magnet Facility at New Mexico State University. It is scheduled for launch in 1993 or 1994.

The question of the amount of antimatter that the universe contains is fundamental to cosmology. While it is clear that matter dominates our own galaxy the question remains whether this asymmetry is local or universal. The measurement of the amount of antimatter and its energy distribution is therefore of greatest importance.

Antimatter has been observed in the galactic cosmic radiation, both in the form of antiprotons and positrons. These species can be produced in collisions between energetic cosmic ray protons and interstellar gas. The amount of data is however rather scarce. Figure 1 shows $\bar{p}/p$ ratio as function of kinetic energy. As can be seen the antiproton data, albeit of low

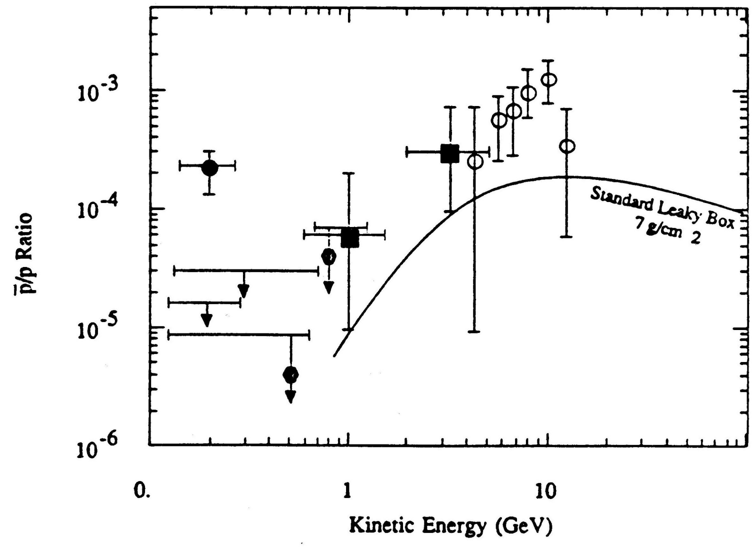

Fig 1. Antiproton to proton ratio in the galactic cosmic rays. From S. Stochaj (1990) Thesis, University of Maryland

statistical significance, suggest that the amount of $\bar{p}$ is in excess of what can be expected from secondary production.

The aim of the CAPRICE project is to measure the antiproton energy distribution over the approximate kinetic energy range 1–6 GeV. It is in this energy range where the shape of the spectrum is of importance for understanding the production mechanism.

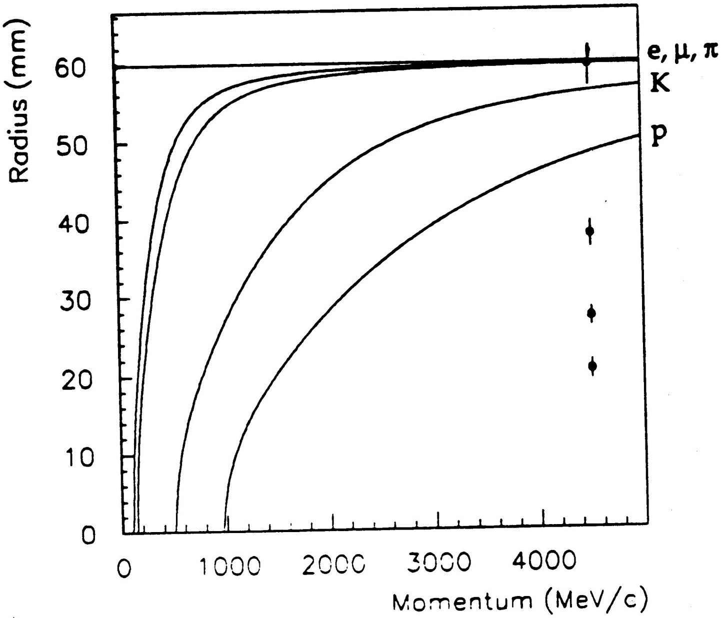

Fig 2. Ring radius as a function of momentum for different particles. The points with error bars illustrate the measured resolutions. From T. Francke (1991) Thesis.

The experimental difficulty in measuring antiprotons – and other unfrequent parts of the cosmic radiation – is the safe identification in the presence of a much larger backgrund of negatively charged muons and pions. The unique feature of the CAPRICE project is the novel type of particle identifyer, a Ring Imaging Cherenkov Counter (RICH) with solid radiator. This particle identifyer was developed at CERN, Geneva. The Cherenkov light is detected in a proportional chamber approximately perpendicular to the particle trajectory at some distance from the radiator. The radius of the Cherenkov ring is shown in Figure 2 as function of the particle momentum. The measured resolution allows a safe identification of antiprotons over the momentum range 1–6 GeV/c. The detector is also very useful for the identification of lower energy (<1 GeV) positrons as well as for some isotopes (^{2}He, ^{3}He). Figure 3 shows the RICH counter in the magnet spectrometer.

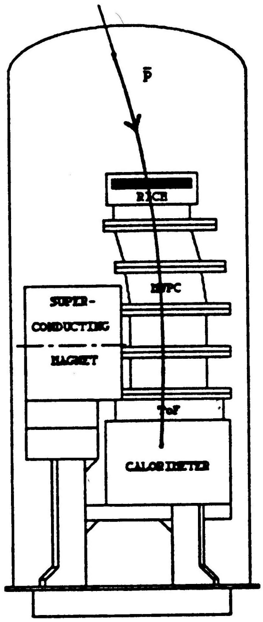

Fig 3. Schematic view of the ballon borne spectrometer with the RICH counter. The spectrometer is about 2 m high.

Division of Atomic Spectroscopy, Department of Physics
University of Lund,

Address: Sölvegatan 14, S-223 62 Lund, Sweden,

Dr Sveneric Johansson

Laboratory Astrophysics Programme

The identification of physical processes and chemical constituents as well as the determination of plasma parameters in stellar atmospheres depend on the quality of the atomic data, that are involved in the analysis. The development of high-resolution spectroscopy in space, at ground-based observatories and in the laboratory allows more detailed investigations of cosmic objects than have previously been possible. The research program in Laboratory Astrophysics aims at getting a deeper and more accurate interpretation of spectra of various kinds of cosmic objects that are observed with space-borne instruments. Participation in space observations, analysis of the stellar spectra recorded and laboratory measurements of atomic quantities, particularly needed for these analyses, are the major contributions from the group in a number of national and international collaborations, some of which are highlighted below.

Activities during 1990 and 1991

In collaboration with Dr D S Leckrone, NASA/Goddard, the group participated in the analysis of the *first observation of a scientific target with the Hubble Space Telescope (HST)* in the beginning of October 1990. Within Dr Leckrone's GTO project on chemically peculiar (CP) stars the spectrum of χ Lupi was recorded with the Goddard High Resolution Spectrograph (GHRS). New echelle observations of the same star were performed with the GHRS in Februari 1991. The resolving power of 87000 permitted the verification of a strong isotope anomaly of mercury in the star's atmosphere, where Hg is heavily concentrated in the form ^{204}Hg. In April 1991, the same star was observed with the echelle grating in five different 10 A intervals, centered around mercury lines.

The HST observations of χ Lupi contain spectral features from a number of heavy elements, for which the laboratory data are incomplete, e.g. As, Zr, Ru, Pt, Au. Two basic atomic parameters in the analysis are the wavelength and the oscillator strength, which determine the shape of the spectral curve together with damping parameters. The echelle spectra of this sharp-lined star have a wavelength accuracy of about 1-2 mÅ, which should be compared to the uncertainties of most tabulated laboratory wavelengths of about 10-15 mÅ. For most species there are no experimental values of the oscillator strength available.

With a new Fourier-transform-spectrometer (FTS) for the vacuum- ultraviolet (VUV) region, installed in the laboratory in September 1991, measurements of wavelengths accurate to 0.1 mÅ can be made and get relative intensities and relative oscillator strengths. In combination with laser measurements of lifetimes these data will provide absolute line strengths within 10%, which allow an abundance determination of chemical elements with about the same accuracy. These data indicate an overabundance of heavy elements, like Zr, Ru, Pt, Hg and Au, by orders of magnitude compared to the sun.

New HST-observations within Dr Leckrone's GTO project are scheduled in the end of March 1992, this time of the Hg-Mn star $\varkappa$ Cancri. For this purpose we are now recording FTS-spectra of Mn II, for which hyperfine structure has to be taken into account in the laboratory analysis and included in the synthesis of the stellar spectrum.

A current project on the analysis of IUE spectra of very hot stars have resulted in the identification of four and five times ionized iron-group elements, in particular Fe V and Fe VI. Transitions from energy levels at about 30 eV in these ions appear in absorption in the IUE spectrum. A number of absorption features have been identified as recombination lines of O V and N V. This is a joint project with Dr F Bruhweiler, Washington DC, USA.

Participation in the analysis of the solar spectrum in the near infrared, recorded with the ATMOS satellite has taken place. This work is a collaboration with people from Brusselles (Sauval), Liège (Grevesse) and London (Nave). The identification of highly-excited Fe I lines opens up a possibility to make an independent determination of the iron abundance in the sun from recombination lines.

Future plans

Future activities will very much be determined by the group's participation in GHRS observations with the Hubble Space Telescope. Besides the collaboration in the GTO-program on CP stars, participation in two other HST-projects that have been selected for Cycle 2 observations, one on the boron abundance in pop II dwarfs and one on a complete spectrum of Sirius is planned.

The remaining discrepancies between the observed spectrum of χ Lupi and the synthetic spectrum, based on an LTE stellar atmosphere, are most probably due to deficiencies in the atomic data base. There are three different problems: 1) Uncertainties in wavelengths. Accurate wavelengths are eg. necessary for studies of hyperfine structure and isotope shifts in stellar spectra as well as for synthesizing blends. 2) Uncertainties in oscillator strengths. Accurate oscillator strengths are necessary for abundance determinations and for the test of LTE-conditions. 3) Unknown lines. Some lines in the observed spectra remain

unidentified, some of which may be due to elements that have not been studied in the laboratory in the VUV region.

The future laboratory program will be guided by the objective to improve the match between the observed HST spectrum and the associated synthetic spectrum. This is valid for all the HST projects involved. Besides short-term projects on particular atomic transitions long-term projects and remeasure spectra of elements having a high cosmic abundance will be performed. Scientific contribution to the HST-project on the boron abundance will also include laboratory measurements of boron, especially the isotope shift.

The HST-project on Sirius will result in an atlas of the stars and the contribution will be to perform the line identifications. It is foreseen a possibility to extract astrophysical f-values from this spectrum as well as from other high-resolution space spectra.

The project on spectra from hot stars will continue with the use of the Extreme Ultraviolet Explorer, which is planned to be launched in 1992. The satellite will open up the spectral region below the Lyman limit, where the resonance radiation from multiply charged ions occur.

Department of Casting of Metals, Royal Institute of Technology

Address: Royal Institute of Technology, S-100 44 STOCHOLM

Prof Hasse Fredriksson
T. Lic. Lars Ekbom

The space program at the department is divided into three main projects as presented below.

INFLUENCE OF NATURAL CONVECTION ON STRUCTURE AND SEGREGATION DURING SOLIDIFICATION (GAS PROJECT 1)

Activities during 1990 and 1991

Natural convection during a solidification process has a large influence on the solidification structure as well as on the distribution of the alloying element. In order to analyse the effect of gravity on those phenomena one experimental set up has been constructed. The construction of the equipment was finished during the period. The experimental set up was flown with the shuttle as a Gas-canister in January 1992.

Some preexperiments was performed during the period. Those experimental results were numerical analysed. One report which will be published in Met. Trans. has been finished.

In parallel with the construction of the solidification equipment theoretical analysis of the structure formation during a solidification process has been performed.

Planned activities 1992 and further

In the beginning of 1992, the GAS-canister was flown, during 1992 modelling and further analysis of both microgravity samples and normal gravity reference samples will be done. New experiments are planned in order to study the influence of gravity on the structure formation during a solidification process.

NUCLEATION AND GROWTH OF SMALL CRYSTALS IN LIQUID METALS

Activities during 1990 and 1991

During the period the dissolution and precipitation behaviour of carbides in liquid aluminium, alloyed with titanium, has been studied. Ground based reference experiments, as well as parabolic flight experiments has been made in cooperation with the Swedish Space Corporation (SSC). The microgravity experiments were made during 14th ESA

campaign at Centre d'Essais en Vol (CEV) in Bretigny-sur-Orge, France. The campaign took place during nine days, from September 19 to September 27, 1991.

Similar, ground based, experiments are being done in the iron, carbon and titanium system to study the carbide dissolution and precipitation behaviour.

Planned activities 1992 and further

During 1992 parabolic flight experiments are to be done, to study the precipitation and dissolution behaviour of carbides in the iron base system, described above.

The results and experimental equipment will be presented during the VIIIth European Symposium on Materials and Fluid Sciences in Microgravity, 12–16 April, 1992 in Brussels, Belgium. During 1992 studies will be undertaken to study the reaction between aluminium base alloys and graphite. This will be preliminary studies for a space shuttle experiments, to be flown during 1993 or 1994.

LIQUID PHASE SINTERING OF TUNGSTEN COMPOSITES UNDER MICROGRAVITY; EFFECT OF MATRIX COMPOSITION

Activities during 1990 and 1991

Tungsten heavy metals are composites consisting of tungsten particles in a Ni-Fe-W- matrix. They are fabricated from powders by liquid phase sintering at 1470°C, during which the tungsten particles are growing in the liquid matrix phase. Texus flight experiments were used to study of the mechanism of liquid phase sintering. For short time tests of this system parabolic flights were performed.

At earlier Texus flights in No 10 and 19 the growth rate and agglomeration of tungsten particles under microgravity were compared to that under gravity and sedimentation. During 1990 the Texus 26 and 27 samples of different W/matrix surface energies were liquid phase sintered. The different alloys used are shown in Table 1. The experiments on Texus were performed using a furnace from ERNO, TEM 01 for 5 min.

Parabolic flight experiments have been performed. Samples of 7 alloys were liquid phase sintered during 3 flights using six mirror furnaces, modified MF, from Swedish Space Corporation. Samples with different surface energy were liquid phase sintered for two different times 8 and 13 seconds.

Table 1. Composition of the eight alloys used at the experiments.

Alloy	Particle fraction	Powder mixture	HIP temp	Texus flight	Sinter time, s/ particle diam, μm
1	4 vol%	W+Ni+Fe	1400°	19	270/6.6
				26	215/6.0
2	18 vol%	W+Ni+Fe+S	1350°	27	290/10.2
3	4 vol%	W+Ni+Fe+Co	1400°	26	255/7.3
4	18 vol%	W+Ni+Fe	1400°	19	270/7.2
5	25 vol%	W+matrix	1150°	10	40/5.9
6	50 vol%	W+matrix	1150°	10	30/5.2
7	9 vol%	W+Ni	1375°	27	60/7.1
8	9 vol%	W-Ni-Co	1400°	-	

The particle growth and the separation was compared to theories. The influence of sedimentation on the growth and separation of the particles has been evaluated, Table 1.

Fig 1 shows the calculated curves for 4% particle alloy liquid phase sintered under gravity in the laboratory compared to the curve calculated from Texus 26 microgravity sample. Data from the parabolic test are included. Under gravity the tungsten particles are sedimenting to the bottom and the particles are closer together, which gives a higher growth rate. The effect of surface energy on the particle separation and growth has been found to be considerable. After 13 sec. liquid phase

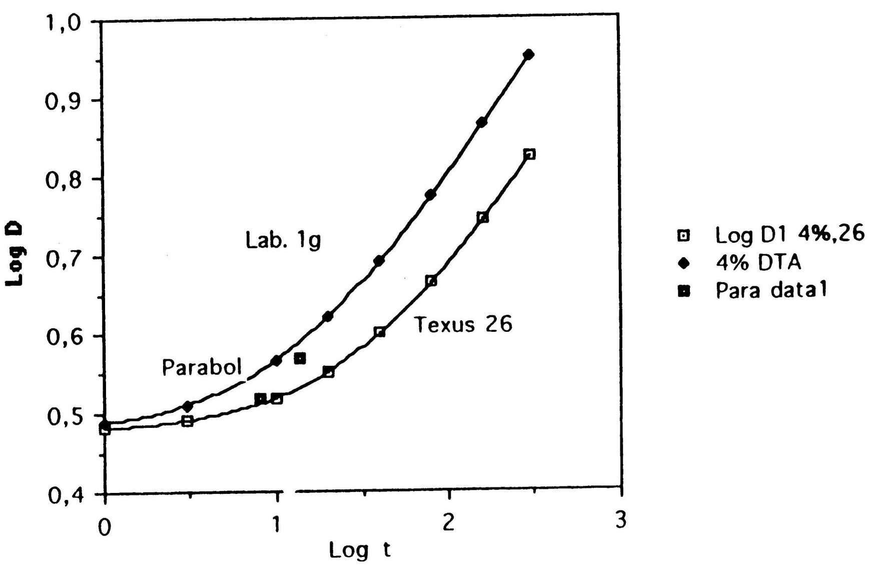

Fig 1. Growth rate of the 4% particle W-Ni-Fe-alloy.

sintering at parabolic flights the liquid has penetrated the tungsten particle agglomerates and the particles have become spherical.

Planned activities 1992

The results from the microgravity experiments are further evaluated and the results will be reported.

Crystal Growth Group, University of Sundsvall

Address: University of Sundsvall, P.O. Box 860, S-851 24 Sundsvall

Dr Torbjörn Carlberg

An important property of semiconductor crystals is the dopant homogeneity. If the crystals are grown from a melt, the convection in the melt often has a strong influence on the dopant distribution in the grown material. The natural driving force for the convection is density differences influenced by a gravity field. The microgravity environment of space is therefore used to avoid this, so called, buoyancy driven convection. The aim of the groups activities is to increase the knowledge of the coupling between the melt convection and the chemical homogeneity of grown crystals. This is done by performing crystal growth experiments under different convection conditions varying from forced strong convection on earth to weak or no flows obtained in space. Along that path an exploitation of the possibilities to produce improved materials in space is done. Crystals can be grown by many different techniques. The main activities are concentrated on melt growth, and especially by the floating zone and Bridgman techniques. In floating zones the surface tension driven convection (Marangoni convection) plays an important role. One of the main topics of the research activities is therefore to increase the understanding of the Marangoni convection, i.e. to study the parameters influencing the different flow regimes. This has to be done under microgravity conditions to avoid coupling with bouyancy forces.

Activities during 1990 and 1991

Preparations for an experiment in the german space shuttle mission D2 has been going on. Ge crystals will be grown by the floating zone technique. A technique has been developed to in situ monitor growth rate fluctuations, which in turn are indicative of unsteady convection. By changing the aspect ratio of the liquid zone during flight, through voice contact with the astronauts, the transition from laminar to unsteady convection will be followed.

A floating zone experiment has been performed during a parabolic flight with KC-135 in U.S. The experiment was performed in cooperation with a canadian group. A Ge crystal was grown during 8 parabola, i.e. the g-level was cycled 8 times from a high level (1,8) to a low level of about 0.01 with the latter periods lasting for 25 seconds. Concentration transients coupled to the different g periods could be studied.

Preparations for a GAS experiment has been going on. The experiment is designed to study the interface breakdown in a growing Ge crystal. A

technique has been developed in which the interface shape, growth rate and temperature gradients accurately can be followed during accelerating growth rate.

An ESA study of the possibilities to use a laser as heat source for high temperature space experiments has been conducted. Especially for floating zone crystal growth a tailored heat flux to the liquid zone might be a way to control Marangoni convection.

Plans for the future

The experiments for which preparations have been going on for several years, i.e. the GAS and D2 experiments mentioned above, will hopefully fly in a near future. Probably in the beginning of 1993. An experiment in which a laser is used for floating zone growth during a sounding rocket flight will also be performed (approved by ESA), however, no specific flight has been decided. The latter experiment and another focused on radial segregation during weak convection are under consideration for a flight in one of the COLUMBUS precursory missions.

Ground based research are being performed in a floating zone furnace in which the heat flux to some extent can be modified.

Environmental Physiology Laboratory, Karolinska Institutet

Address: Department of Physiology, Karolinska Institutet, P.O. Box 60400, S-104 01 Stockholm, Sweden

Prof Dag Linnarsson
Dr Per Tesch

Research programme

In the space-related activities of the department, gravity is used as an investigational tool for the study of fundamental physiological phenomena in the human body. In particular, the areas of interest are in the functions of the lungs, the blood circulation, the body fluids and the skeletal muscles.

Lung function in microgravity. It is generally recognized that gravity has a profound effect on the distribution of blood flow and ventilation of the lungs. This hypothesis, however, remains to be proven by experimentation in microgravity. An important element in our research program is therefore to develop methods for the non-invasive study of lung gas and lung blood distribution in man. These methods will then be used for the study of lung function in microgravity during parabolic flight and during space flight.

The oxygen transport and utilization during exercise in microgravity. Gravity influences the efficiency of muscular work i.e. the oxygen cost of a given mechanical power output. The mechanisms behind this phenomenon are not fully understood, and studies of leg exercise in microgravity will increase our understanding of the factors normally determining the efficiency of muscular work.

Control of arterial blood pressure during exercise. The arterial blood pressure at the level of the neck is closely controlled during rest and exercise in order to protect the brain from too high or too low blood pressures. Short-term microgravity during parabolic flight, and long-term microgravity during space flight offer unique experimental models to study the dynamic and static properties of the arterial blood pressure control system in the intact man, because of the absence of hydrostatic pressure gradients in the body.

Muscle function. In normal gravity, and in the upright position large muscle groups are constantly activated against gravity. This constant activation is eliminated during space flight. Previous space flights have demonstrated loss of strength and skeletal muscle mass, changes similar to those seen in bedridden patients. The fact that completely healthy individuals can be studied during long periods of complete muscle unloading renders microgravity a unique and potent scientific tool to study the factors regulating the structural, biochemical and functional properties of skeletal muscle. Experimental studies include ground-

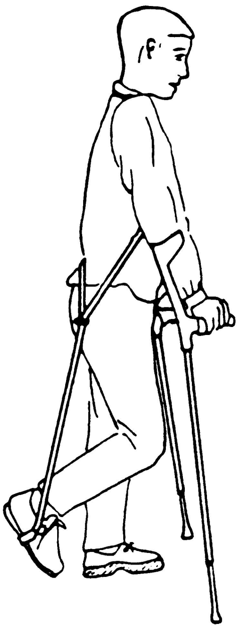

Fig 1.

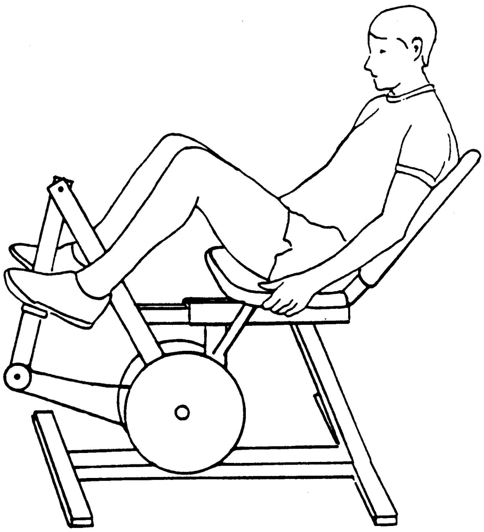

Fig 2.

Fig 1. Human unilateral lowerlimb suspension model to simulate the muscle unloading in microgravity.
Fig 2. Gravity-independent strength ergometer for resistance training of postural muscle groups to be used as an exercise countermeasure during long-term spece-flight.

based simulations and development of training procedures for use as countermeasures to inactivity-induced losses of muscle mass and strength.

Simulation of microgravity on skeletal muscle. Skeletal muscles, and in particular those of the lower limbs, show decreased size and deteriorated strength and function following exposure to weightlessness. There are limited oppurtunities to study these effects on humans and most studies conducted so far have been performed on lower mammals. Therefore, at Karolinska Institutet the team has developed a human model, which simulates the conditions prevailing in space e.g. unloading of the lower limbs (Fig 1). The studies carried out so far using this model have been aimed at describing changes in muscle size and function. It is shown that similar reductions compared to those reported in response to bedrest and therefore the model appears to be valid to simulate space flight.

An ergometer to be used for resistance training in space. The scientific group has proposed that the decreases in muscle mass and strength that occur during long-term space missions can be counteracted by heavy - resistance training. Unfortunately, there are no ergometers for strength training available developed to function effectively in weightlessness.

Therefore a mechanical self-powered device, which is based on the fly-wheel principle, has been developed (Fig 2).

Activities during 1990 and 1991

Preparations for participation in the Spacelab flight D-2, scheduled for early 1993 have included the following activities:

- Evaluation has been performed of ESA-developed hardware to be included in Anthrorack, a double rack of instrumentation, which will support the experiments during D-2. A training model at Microgravity User Support Center, Cologne, Germany, and a flight model at ERNO/MBB, Bremen, Germany, have been tested.
- Training of astronauts in experimental procedures is in progress. The experimental protocol is an integration of Swedish, Danish, Belgian and German experiments.
- There has been a continued development of methods for studies of pulmonary and cardiac functions using soluble and insoluble inhaled indicator gases. Dose/response studies of their influence on psychomotor performance and temperature control demonstrate that the used concentrations are several orders of magnitude less than those giving pharmacological effects.
- Parabolic flight experiments have been performed on the CNES Caravelle at Brétigny-sur-Orge in France. Blood circulation and gas exchange has been studied during the first instants of the transition into microgravity in upright exercising subjects. Data show that the initial stimulation of the cardiac output is extremely shortlasting.
- A ground-based model of the blood circulation in the exercising leg in microgravity has been studied further. Effective blood flow in the working muscle can be estimated to be reduced by some 20 per cent in microgravity. This is despite a compensatory increase of the arterial blood pressure.

Other ground-based research and development activities have been pursued in preparation for future Columbus or Columbus precursor flight experiments:

- The research group has evaluated the suspension model by experimental studies including a 4 week unilateral unloading study in healthy volunteers. Maximal voluntary force and endurance of the knee extensors and muscle mass, as estimated by computerized tomography (CT), were monitored before and after unloading and after a recovery period. A 20 per cent decrease in muscle strength combined with a 7–10 per cent loss in muscle protein content over this time period is very similar to the changes reported by others after one month of experimental bed rest. Strength and to a lesser degree endurance was partially regained during the first days of recovery. We conclude that this model is a valid simulation of microgravity which

permit extensive ground-based studies on the time course of muscular adaptation to unloading.

- The strength ergometer has been developed and is currently under physiological evaluation through a series of ground-based studies. These include measurements of force, work, biokinetics, electromyographic (EMG) activity and energy expenditure while performing resistance training sessions by means of seated maximal leg press exercise involving the hip, knee and ankle extensors. During exercise using strength ergometer force development and EMG-activity comparable to traditional heavy-resistance equipment have been recorded together with a low metabolic cost.
- The department has participated in the national selection process for European astronaut candidates.

Future plans

- Baseline collection of 1G control data for the D-2 flight will be obtained in Cologne 360, 270 and 180 days before the flight, in the US 60 and 15 days before and finally 1, 4, 7 and 15 days post flight. During these sessions all flight experiments will be performed at 1G using flight-identical equipment.
- The D-2 flight experiments will be performed during a 9-day Spacelab mission early 1993. Four astronauts will serve as operators and subjects.
- Analysis of D-2 flight and control data will take place during 1993 and 1994.
- Ground-based studies of pulmonary gas exchange, respiratory control and cardiovascular control during rest and exercise will be performed in preparation for Columbus and Columbus precursor flight experiments.
- Continuation to carry out ground-based experiments to study the effects of simulated weightlessness on structural, metabolic and functional properties of human skeletal muscle. These studies will in detail describe adaptations of protein synthesis and activation of muscle.
- The ergometer is planned to be flown and evaluated during parabolic flights. In ground-based experiments it will be further evaluated by means of its feasability to be used to combat decreases in muscle size and function during simulated weightlessness.

Department of Physical Chemistry, Chalmers University of Technology

Address: Department of Physical Chemistry, Chalmers University of Technology, S-412 96 Gothenburg, Sweden

Prof Bengt Nordén
Dr Mats Jonsson

The research activity at the Department of Physical Chemistry includes basic scientific research in the DNA field, mainly spectroscopic and electrophoretic research exploiting and developing methods for characterizing structure, dynamics and interactions in DNA systems or for analytical and preparative separation of DNA.

Electrophoresis in gel-stabilized solution has been a key tool in molecular biology since several decades for separation of DNA. The method is used preparatively for purification, and analytically for identification and characterization (determination of the base sequence). As a consequence of increasing complexity and more difficult separation problems, such as separation of large DNA:s in the human genome project, great efforts are made to increase the resolution power of the technique.

In one of the current projects at the department the transport properties of DNA during electrophoretic migration in gels are studied and analyzed, experimentally as well as theoretically, to get a better insight into the mechanisms that are operative on a molecular level. Increased knowledge about how molecular interactions, and interactions with external electric and hydrodynamic fields, influence the conformation and dynamics of the molecules is a requirement for progress in the development of existing electrophoretic techniques and for the creation of new techniques. A cardinal basis for our experimental research is the discovery at the department, a few years ago, that DNA molecules during migration in electrophoretic fields become macroscopically oriented parallel to the direction of migration and that the DNA alignment can be sensitively and selectively quantitated by the light absorption anisotropy known as linear dichroism (LD). From the time-dependence and the steady-state values of the LD of DNA it has been possible to quantify the degree and dynamics of the orientation of the molecules as they respond to the electrophoretic field and as they migrate and become deformed by interactions with the surrounding gel. The orientational behaviour in the two most common types of electrophoretic gels has been investigated and the results have given important understanding about the dynamics and interactions that are responsible for the separation of DNA.

Electrophoretic orientation experiment in microgravity

For mechanistic considerations and for the development of capillary electrophoresis (CE) the study of orientational effects in free solution is also of interest. In the fine capillaries used in CE the efficient heat conduction to the walls eliminates the need for the anticonvective properties of a gel, and therefore separations can be performed in free solution under very high field strengths, where both dipolar type of orientation and electrophoretic orientation of the migrating molecules can be anticipated. However, LD measurement in thin capillaries gives too low signals to allow safe conclusions. The scientific group is therefore working with larger cells where, however, heat convections are unavoidable. The presence of convection may affect the orientation of the molecules and, furthermore, motion of thermal refractive gradients can produce optical artifacts. In a project supported by European Space Agency (ESA) and the Swedish National Space Board, an investigation of measurement under microgravity conditions, where heat convections are eliminated, would produce results different from those on the ground is performed.

Activities during 1990 and 1991

The group participated with an electrophoretic orientation experiment in the Maser 4 sounding rocket flight in March 1990. The sample was a high molecular-weight DNA dissolved in a normal electrophoresis buffer. The equipment developed for measuring the LD of the DNA consisted of a low-pressure mercury lamp, a linear polarizer, an oscillating photoelastic modulator, a photomultiplier, and a phase-sensitive amplifier. The sample cell was closed and its electrophoresis chamber, where the optical measurements were performed, was cylinder-shaped and made of birefringence-free silica. Square-formed electric field pulses of different strengths were applied over the sample cell. The LD measurement showed that the build-up of the orientation occurs via a state of high orientational order, a behaviour which has been reported only for large DNAs when in gels. However, the signal to noise ratio in the flight experiment was lower than expected, which obviated safe conclusions about the detailed behaviour of the DNA. The equipment was therefore reconstructed and a new flight was performed on Maxus 1 in May 1991. Microgravity was never reached in this flight due to an accident with the rocket, however, a reflight is scheduled in the near future.

Future plans

If the Maxus reflight turns out well continued work in microgravity is justified. However, a complete understanding of the studied effects

requires systematic studies under varying experimental conditions and interactive experimental operation. This demands a much longer microgravity time than can be obtained with the sounding rockets. An experiment on Spacelab E-1 has therefore been proposed in a facility developed from the sounding rocket experiment module facility.

Atomic Physics Division, Department of Physics, Lund Institute of Technology

Address: P.O. Box 118, S-221 00 Lund, Sweden

Prof Sune Svanberg

At the Division of Atomic Physics, Lund Institute of Technology, an extensive research program in basic and applied spectroscopy is being pursued. Most of the work falls in the category of laser spectroscopy. The division, comprising about 50 staff members and graduate students, is responsible for the basic physics teaching at the Lund Institute of Technology and the specialized teaching in atomic physics, optics, atomic – and molecular spectroscopy, and laser physics. Research programs include high-resolution and time-resolved laser spectroscopy of free atoms, combustion diagnostics, medical diagnostics and, finally, optical remote sensing with active techniques. This report only deals with this latter activity, which is supported by the Swedish National Space Board and the Swedish National Environmental Protection Agency.

Laser Remote Sensing of the Atmosphere (LIDAR)

Remote sensing of atmospheric pollutants is being pursued using the lidar (light detection and ranging) technique. Pulsed, laser radiation is transmitted into the atmosphere and backscattered light is collected with an optical telescope. The optical transients are detected by a photomultiplier tube and after computer processing range resolved information on the pollution concentration is obtained. The activity is supported by spectroscopic measurements performed using a White cell absorption system. A mobile lidar system with a tunable laser source is used for techniques development and field work. By measuring in different directions and using specially adopted computer routines pollution maps are automatically produced. Fully operational status has been reached for SO_2, NO_2 and O_3. The system participated in the TROLIX campaign in Bilthoven, The Netherlands, June 1991 within the EUREKA/EUROTRAC subproject TESLAS.

Extensive measurements of Hg have been performed at industrial complexes like chlor-alkali plants. Mercury monitoring is also motivated by geophysical interest, since this gas might be used to trace ore deposits, geothermal activity etc. Measurements at a mercury mine and at geothermal power-plants in Italy have been performed. Demonstration measurements have also been performed for NO and Cl_2.

A fixed vertically sounding ozone lidar system utilizing a KrF excimer laser transmitter has been constructed and will be used in the EUREKA/EUROTRAC subproject TOR.

Differential Optical Absorption Spectroscopy (DOAS)

Using a high pressure xenon lamp in combination with a receiver telescope and a fast-scan spectrometer, path averaged concentrations of important air pollutants can be measured for distances up to 5 km. In addition to major air pollutants such as SO_2, NO_2 and O_3, photochemical intermediates at very low concentrations can be studied. Recent work includes studies of NH_3, that is responsible for considerable pollution in certain regions. Extensive laboratory and field work on more efficient O_3 detection has been performed. A DOAS system was used in the TROLIX campaign mentioned above to support the lidar systems with ground level data of O_3 and SO_2 as well as providing aerosol attenuation measurements using a new measurement strategy.

Industrial production of DOAS instruments is pursued by a Swedish company.

Laser-Induced Fluorescence Studies of Marine Pollutants and Vegetation

Using laser-induced fluorescence, marine pollutants such as oils can be detected remotely as well as algal blooms. Measurements of the Arno river in Italy have been published. Another field of interest for the group is the study of vegetation stress. The group participates in the EUREKA/EUROTRAC subproject LASFLEUR developing a new multispectral remote imaging technique.

Department of Biometry and Forest Management, Swedish University of Agricultural Sciences, Umeå

Address: Remote Sensing Laboratory, Swedish University of Agricultural Sciences, S-901 83 Umeå, Sweden.

Prof Robert Sylvander
Prof Sipi Jaakkola

The laboratory is working within satellite remote sensing with special reference to forestry and agriculture. An increasing emphasis is laid on environmental aspects.

The laboratory is equipped for image/GIS analysis with SUN-SPARC IPC work stations running ARC/INFO, ERDAS, GRASS and PC:s running PC ARC/INFO and IDRISI.

Some examples of major projects are as follows:

The use of a computerized method for delineation of forest stands and the estimation of forest stand data based on satellite spectral values. In order to test the concept in practice a PC-based prototype GIS/Remote sensing work station was developed. The functions were implemented on a 386- PC and was tested during the summer of 1991. When conditions typical for major forest companies are assumed the methodology compares very favourably to conventional methods. Improvements and modifications will be made to the prototype system to develop a complete set of functions for data exchange, image segmentation and interactive editing. During 1992 the system will be evaluated practically.

Another project is directed towards developing methods for change detection of forest stands. Satelllite data from several consecutive years are compared and different statistical methods are used for detection of changes. Examples of changes that could be detected were snowbreaks, heavy fungus infections, thinnings of certain intensities as well as more apparent changes as clear cuts and new roads etc.

The usefulness of the American GPS (Global Positioning System) has been studied for forestry applications. The accuracy of obtained positions seems to be satisfactory for many applications such as aerial photography, positioning of permanent sample plots on the ground, navigation support for different types of ocular estimations from aeroplane or helicopter etc.

Analysis of radar data for forestry applications. This work is undertaken in cooperation with the Department of Radio and Space Science at the Chalmers University of Technology. So far polarimetric multifrequency SAR data from the MAESTRO campaign have been analyzed. Data from L and P- band have been found more useful for forestry applications than C-band data.

Methods for site classification based on digital data are developed.

Forest site variables are determined by analysing a digital elevation model, a soil map, a cadastral map and other available data. The obtained information is used for classification of site index.

The Swedish University of Agricultural Sciences is represented by a few researchers at the Centre for Image Analysis in Uppsala. This centre is a joint reserach centre for Uppsala University, Swedish University of Agricultural Sciences and the Swedish Environmental Protection Agency. The researchers from the agricultural university are mostly working with applications concerning soil classifications and mapping. Crop monitoring is another field of research.

The laboratory in Umeå is regularly giving courses in remote sensing and GIS at the MSc and doctorate level. In total around 80 students are following courses up to five weeks during each year as part of their studies for MSc of Forestry.

The usefulness of radar data (ERS-1, J-ERS 1, RADARSAT) will be analysed for different forest areas in Sweden. The National Forest Inventory carried out by the Department of Forest Survey of the University of Agricultural Sciences will be using satellite data for providing more reliable estimates of forest data especially for smaller areas (standing volumes, areas of cutting etc). More emphasis on environmental monitoring will also be possible in future. Research activities supported by remote sensing and GIS have been initiated at several departments of the Agricultural University both in Umeå and at other locations (Alnarp, Garpenberg etc). The group of the university working at the Centre of Image Analysis in Uppsala is likely to increase and will be working with special emphasis on agricultural projects and environmental aspects. Generally seen there is an increased awareness that remote sensing and GIS applications have a potential which has so far been used only to a very limited extent.

Centre for Image Analysis in Uppsala

Address: Glunten, S-751 83 Uppsala, Sweden

Ass Prof Tommy Lindell

The Centre for Image Analysis was founded in 1988 as a joint research center between the Uppsala University, The Swedish University for Agricultural Sciences and The National Environmental Protection Board.

The objectives of the Centre is to create the knowhow needed for an operative and sensible use of digital image analysis in society, particularly in the fields of environment and medicine.

In order to pursue this goal the Centre conducts basic and applied research in image analysis and remote sensing.

The Centre is organized as a part of the Uppsala University with a status similar to a department. It is directed by a board consisting of three representatives from Uppsala University and two representatives from the other founding bodies and for the personnel organizations.

Under this board a director and deputy director are responsible for the researchers, of which fourteen are graduate students.

Aquatic Remote Sensing

The general objective of the aquatic remote sensing at the Uppsala University is to strengthen the digital remote sensing in general, focused on the fields of bio- and geosciences. At present the university is lacking undergraduate education in digital remote sensing. The coupling to the geosciences creates a natural connection between remote sensing and Geographic Information Systems (GIS).

The group in aquatic remote sensing has more than ten years of experiences from this field, and is thus by far the most experienced in the country. The work started at the Environmental Protection Agency on a cooperative project with the Swedish Space Corporation on Swedish inland waters and has continued with a number of applications through the years.

Remote Sensing in Agriculture and Forestry

The work on remote sensing for agriculture and forestry mainly deals with application projects both in Sweden and abroad (West Africa, Asia).

The material used by the group is earth resources satellite's imagery

(SPOT and Landsat TM data). Classical activities are land use identification and correlation analysis. Multispectral and multitemporal analysis is performed with supervised classifications supported by training sets.

One of the major agricultural application projects concerns soil classification and mapping in cooperation with provincial personnel. Within crop monitoring, procedures are developed for monitoring the areal distribution of the main crop, cereals, oilseed and leyland.

The main overseas engagements concerns the use of satellite imagery for management of natural forest in Burkina Faso, reforestation in Mauretania and for land use statistics in Guinea Bissau in order to improve the classical field data collection.

Current research projects

Aquatic remote sensing

Problems have varied from mapping of waste water discharge and distribution of plumes in lakes and seas to mapping of subsurface ridges in tropical seas. A present study concerns the physical planning of coastal areas. We have been investigating all types of sensors like Landsat MSS and TM, SPOT, MOS-1 and AVHRR. Geographically we have covered almost all of Sweden and been working with data and well-known researchers from Canada, USA, Norway and in a number of developing countries like Sudan, China, Bangladesh, Egypt etc.

Weather satellite data for the monitoring of the Skagerrak and Kattegatt Seas among other things covering the well-known poisonous algal bloom of the Skagerrak during May 1988. This project as well as a number of others are performed in cooperation with NIVA, Oslo.

The outflow of the River Glomma in the Skagerrak is another of those trying to establish the dispersion patterns of the Glomma plume under different weather conditions. All types of sensors from AVHRR over MSS, MOS, TM to the SPOT have been used.

The use of satellite data for the verification of oceanographic models is a third of those projects also in cooperation with Veritec, Norway . The Centre is producing the images used for verification of model of the current patterns as generated by oceanographic models.

The use of satellite sensors for water quality surveillance is a long term project in cooperation with the Swedish Space Corporation. The project has dealt with all types of high resolution data, from MSS, TM, SPOT and now the MOS-1 satellite sensor MESSR. The project has revealed a number of inconsistencies in the treatment of data at different receiving stations and verified the problems with the Fucino MSS data and the problems of calibration of ESA TM data.

Recent oolitic submarine ridges of the world. This project has been

using MSS, TM, MOS-1 and SPOT data for the mapping of submarine recent oolitic ridges, earlier focused on Egypt, where the first ever found recent oolites in the Mediterranien were mapped. Today the project has expanded to include a world wide data base on recent submarine oolites.

Delta developments in connection to the so called "Global Change". This pilot project has concentrated on the conditions in Bangladesh as a model for the global effects of climatic changes on deltas of the world.

Coastal Dynamics research in the Wider Caribbean is a pilot project for initiating modern techniques including remote sensing in management and planning of the coastal zone in the Wider Caribbean arera.

Current research projects in land applications including agricultural remote sensing

Classification of types of grounds in the Qattara depression, Egypt is a follow up of an earlier project including photo interpretation and satellite analysis of different types of grounds in the depression.

The use of satellite data and GIS for the physical planning of Swedish communes. A number of Swedish organizations (among them the SSC) has been involved in a planning effort where the Centre has produced background material for the planning and created a GIS data base with both satellite data and digitized map data as a tool for the planner.

Soil classification project in South Sweden. The top soil of agricultural fields are classified from multitemporal satellite image analysis and it will be integrated with information from many other sources (crop calendar, scanned aerial photographs, scanned soil maps..) in a Geographic Information System for a better understanding of the agricultural landscape and its characteristics.

Crop monitoring project in Central Sweden. Field pattern recognition and the conversion of satellite raster data to vector data will be an important part of the research for the group for production of areal statistics of crop information on the county level. Cooperation for this application in Sweden and abroad is established with the agricultural statistic department of Statistics Sweden (SCB).

Open cut mines in Estonia-a multitemporal remote sensing study. Satellite imagery has been used to evaluate the environmental impact of the vast open cut mines in Estonia and to follow the current efforts to restore parts of the area.

Several research projects in developing countries dealing with **management of natural forest in Burkina Faso, reforestation in Mauretania** and for **land use statistics in Guinea Bissau** in order to improve the classical field data collection.

Future plans

Most projects are long-term activities and for the future most of the image analysis of interest in remote sensing will focus multivariate classification.

The group on aquatic remote sensing will be focusing on the following tasks:

- calibration of satellite systems and optimizing the use of different sensors.
- development of systems for surveilling of aquatic environments.
- identification, mapping and categorizing subaquatic forms.
- coastal dynamics and coastal changes.
- coupling between climate, water currents, coastal development and the production conditions in the seas.

The agricultural applications will focus on segmentation problems and the coupling of different types of data in GIS.

Most of the efforts in the future will gradually change to more integration between image analysis and remote sensing projects. Already in preparatory phases are:

- a continuation of the physical planning project involves both agricultural and forestry experts as well as image analysis and GIS elements.
- treatment of radar data including both filtering tecchniques and applications for water quality and agriculture.

Future developments in remote sensing is considered being highly dependent upon techniques collected from, and developed within, classical image analysis and vise versa. The reason for this is that the new generation of high resolution earth resources satellites generates information which require neighborhood dependent analysis and structural analysis. The standard methods of classifying satellite images is no longer sufficient. On the other hand the image analysis require today more multivariate solutions that could gain experiences from remote sensing. Cooperation between the different groups of the Centre is expected to be very fruitful and will give a still stronger international position.

Department of Geology, Chalmers University of Technology

Address: Chalmers University of Technology, S-412 96 Gothenburg Sweden

Mr Mikael Gråsjö

At the Department of Geology, Chalmers University of Technology, several research projects are carried out, concerning tectonic conditions in the earth's crust. Particular interest is paid to weakness zones in crystalline bedrock and hydrogeological conditions in these zones. Methods have been developed to better predict the existance of groundwater in the bedrock and under development are also methods to monitor water movement in fractures and fracture zones. Extensive statistical analyses have been performed on tectonic elements, from many places both in Sweden and abroad.

Since 1987 the Department has used digital image interpretations on satellite imagery as a tool for mapping large scale lineaments. Currently, several research projects are beeing carried out using SPOT and Landsat TM data in an advanced image processing system. The projects comprise identification of tectonic elements of hydrogeological significance as well as interpretation of other data of value for groundwater exploration. Interpreted data are compiled in a Geographical Information System (GIS) for analyses.

Activities during 1990 and 1991

- Correlation between well yield and lineaments interpreted on enhanced SPOT images as well as correlation between geophysical anomalies and lineaments.
- Comparisons between lineaments identified on satellite images and aeromagnetic lineaments.
- Comparisons between lineaments interpreted in different image scales.
- Incorporation of tectonic elements interpreted on SPOT images with borehole and geophysical data in a Geographical Information System, for detailed statistical analyses.
- Thorough field studies of data interpreted on enhanced satellite images, as well as a field comparison between different types of satellite images in a semi arid area in SE Botswana.
- Beginning the establishment of a multilayered database covering the Gothenburg region. Information in the database include SPOT and Landsat images, geophysical maps, digital terrain models and well data from more than 4 000 drilled wells in the region.

Plans for the future

- To continue developing a combination of high resolution satellite imagery and GIS, to use as a tool in hydrogeological projects.
- To implement high resolution satellite imagery and GIS in groundwater exploration in arid and semi arid areas, especially in developing countries.
- To complete the multilayered database covering Gothenburg. Incorporate digital geological maps (both bedrock and soil) and scanned air photos, as well as detailed field information.
- With the Gothenburg database available, perform advanced correlation studies and geostatistics based on GIS technology.

Remote Sensing Laboratory, Department of Physical Geography, Stockholm University

Address: S-106 91 Stockholm, Sweden

Prof Leif Wastenson
Ass prof Bengt Lundén
Ass prof Wolter Arnberg

Programme

The research activities are focused on developing remote sensing methods for inventory of natural resources and environmental monitoring. Digital image analysis of data from Landsat TM, SPOT and NOAA, and studies of spectral signatures of various natural objects are included in the program. Computer cartography and development of geographical information systems (GIS) is also an important part of the research programme.

Activities in 1990 and 1991

During the last two years the research has been concentrated on the application possibilities of Landsat TM and SPOT images for mapping of vegetation, land use, bedrock geology, and land degradation studies in Africa. Studies of correction procedures for change detection in multitemporal satellite data are performed. Satellite images have also been tested for use in an investigation of the effect of clearcuts on local climate and forest regeneration, and for environmental monitoring and marine ecology research in the Baltic area. Digital enhancement of NOAA images for sea ice mapping under cloudy conditions has been tested. Aerial photos, satellite images, digital thematic maps, and digital terrain models are used for forestry and physical planning purposes in a GIS environment.

The computer resources at the Laboratory has been updated and consist of 4 Sun Sparc workstations, 1 Context Vision GOP 302 an 2 Intergraph IP2020, as well as several PCs in network. Software used at the Laboratory is ERDAS, ARC/INFO, Microstation (SPIM, MGE, etc), and ORACLE.

Closely connected to the research is the education programme for undergraduate and post-graduate students. The Laboratory has also been responsible for the UN International Training Course in Remote Sensing.

Future plans

Studies of the reflectance properties of natural objects

Within the subheading that covers the physical base for remote sensing, concentration on the development of correction strategies for quantitative time series analysis of satellite images is intended. Within part of the IGBP-program, monitoring of changes within drainage basins around the Baltic is one of the topics having priority. The time perspective is 5 – 10 years. Quantification of small and medium amplitude changes in land cover types and biomass requires stringent calibration and correction procedures if the results are to be reliable.

Concentrated efforts on the development of empirical correction techniques involving simultaneous radiometric measurements for calibration is intended. For applications where the physical presence of equipment within the imaged area at the time of satellite overpass is difficult or impossible, we intend to develop calibration techniques relying om reference ojects with known reflectance characteristis within the scene.

Knowledge about the reflectance as a function of the illumination geometry is imperative for these efforts, both regarding different objects and cover types, and also regarding potential reference objects. Investigations on low-reflectance objects such as oligotrophic water bodies, and high-reflectance objects such as bedrock and vegetation-free mineral soils will be in focus.

Remote sensing of bedrock geology

Further studies will be carried out regarding the possibilities to optimally enhance satellite imagery and digital terrain models for mapping of geological structures.

With the measurements of spectral signatures of different rock types in laboratory and in the field, we have a good knowledge of wavelength regions of importance for rock type separation. This will be used in planned projects with the new type of multispectral airborne sensors like AVIRIS (Advanced Visible and Infrared Imaging Spectrometer) with 224 channels. The group has worked with AVIRIS data on a computer compatible tape received from Jet Propulsion Laboratory.

An initiated analysis of Seasat SAR data over a part of the Swedish mountain region will be followed by a comparison with ERS 1 SAR data over the same area.

Remote sensing with thermography

Further studies concerning the potential of Landsat TM thermal band will be performed. With the multiband thermal sensors the technique

has a good potential not only for climatological and hydrological studies, but also for geological investigatione as shown by the results from laboratory research and from analysis of data aquired by TIMS airborne missions.

Remote sensing for land degradation studies

Experience from earlier studies in Lesotho will be a base for a study in Tanzania and Botswana. The objectives of this study are to develop remote sensing methods for assessing changes in vegetation cover and detect land degradation processes, to establish correlation between biomass and remote sensing data to create an effective rangeland/woodland monitoring system and to investigate the relationship between detected vegetation changes/land degradation process and the causes of range land degradation – wildlife, livestock, human activities and climatic change.

Marine environmental monitoring in the Baltic

This is a a project in cooperation to the Department of System Ecology, Stockholm university and the Institue of Ecology and Marine Research in Talinn, Estonia.
The project will include

- Mapping and quantification of algae biomass in the coastal zone
- Remote sensing for quantification of the flowering of plankton in the free water
- Studies of water exchange between the coastal zone and the open sea area
- RS methods for monitoring of changes in land use within drainage areas as a basis for modelling of nutrient leakage.

The project will run in Swedish and Estonian test areas.

The Lund Research Group in Applied Monitoring and Environmental Analysis, Remote Sensing and GIS Laboratory, University of Lund

Address: Dept. of Physical Geography, Sölvegatan 13, S-223 62 Lund, Sweden

Dr Ulf Helldén
Dr Lennart Olsson
Dr Karin Hall-Könyes

Research programme

The group develops, tests and applies methods for environmental and ecological monitoring, mainly in African drylands, for research of interactions among humans, climate and land. The main objective is to analyse and document deforestation, degradation and desertification problems, with special reference to Africa, for better understanding, in Sweden and internationally, of their causes, processes and consequences. The group contributes through post-graduate training, its doctoral program and independant research.

The Lund group is the only group in Scandinavia, and one of the very few in the world, that is specialised in, and which has devoted the major part of its dedicated resources, to monitoring and regional analysis of desertification and natural resources in African environments.

Activities during 1990 and 1991

Remote Sensing and Geographical Models for Studies of Natural Resources in African Drylands.

Calibration of NOAA AVHRR Data for Studies of Soil and Vegetation Conditions in Arid and Temperate Environments.

Geographical Information Systems for Landscape Analysis – Erosion.

Modelling in Tropical Environments.

Rainfall, Agricultural Production and Famine in Ethiopia.

Evaluation and Land Management Activities in Tunisia.

Early Warning Systems

Remote Sensing in Swedish Agriculture.

Studies of the development of mechanized farming and its environmental influence in the Kassala province, eastern Sudan.

GIS for Coastal Planning, Management and Control.

Erosion and sedimentation in the Khashm el Girba dam and its drainage basin, the Sudan/Ethiopia.

Processing and Correction of NOAA-AVHRR Data for Landscape Studies.

Plans for 1992

The projects active during 1990 and 1991 will proceed during 1992. One new project has been initiated:

Development of Geographical Information Systems for Monitoring and Spatial Modelling of Nitrogen Leakage and Transport.

Environmental and Natural Resources Information Systems, Royal Institute of Technology

Address: S-100 44 Stockholm, Sweden

Prof Friedrich Quiel

The research program concentrates on the development and application of techniques to collect, store, analyse and present geographically referenced data. Geographic information systems (GIS) and digital image processing of remote sensing data are the main research activities related to space.

The space related activities in 1990 and 1991 can be summarized under the following topics:

Evaluation of SPOT data for updating of land use information

High resolution spaceborne data, e.g. SPOT, pose serious problems in the digital evaluation of built up and other highly structured areas. Classical multispectral classification using maximum likelihood procedures provides only unsatisfactory results. Therefore a combination with other techniques has been investigated, consisting of a number of steps:

- Unsupervised and supervised classification to create spectral land cover classes, using e.g. existing but obsolete land use information as base.
- Extraction of spectral objects and determination of their size and neighbours.
- Reclassification of the spectral objects into land use classes based on their spectral characteristics, size and neighbours.

Results so far indicate a significant improvement in classification accuracy.

Application of GIS and remote sensing in water resources assessment

Remote sensing techniques can provide valuable input information for a GIS and for modelling and simulation to manage water resources. Landsat Thematic Mapper data have been evaluated to extract information on soil characteristics, vegetation cover and crop types in Zimbabwe and southern India. This information is then used in models to assess water requirements in large irrigation projects and the surface runoff and related erosion risk.

Results so far indicate that Landsat TM data provide a more detailed image of the distribution of different soils in the project areas than

published soil and geological maps. The detailed identification of crops on individual fields in India is limited due to the small field sizes, but significant patterns in the local and regional distribution of major crop classes became evident.

Plans for the following years

Research and development will concentrate on Geographic Information Systems with remote sensing techniques as an important information source. The development and use of knowledge based systems will be a major goal in our work. The continuation of the above mentioned research projects will be combined with new activities resulting in these main topics:

- Integration of GIS, digital image processing of remote sensing and geophysical data and other software, e.g. for simulation. This includes the development of a geographical query language and suitable data models.
- Development of analysis, modelling and simulation techniques for natural resources and environmental impact studies. Models for surface runoff and erosion risk are a typical example. Remote sensing data are in many cases vital to provide important information e.g. on vegetation cover.
- Combination of various image processing and analysis techniques under the control of a knowledge based system to consistently identify major land use classes in spaceborne data.

Swedish Environmental Research Institute, Stockholm

Address: P.O. Box 210 60, S-100 31 Stockholm, Sweden

Mr Sam Ekstrand

Research Programme

The main objective is to strengthen the knowledge within environmental remote sensing and to develop methods for remote detection of environmental effects on biomass. The problems addressed are:

- Assessment of defoliation on Norway spruce using satellite data and airborne spectrometers. Integration of elevation models and digitized forest maps to reduce error sources like terrain effects and variations in age, density and species composition.
- Detection of eutrophication effects in coastal waters using satellite data and airborne spectrometers. Of specific interest is the mapping of chlorophyll *a* during algae blooms.

Activities during 1990 and 1991

During most of 1990 and 1991 the work was concentrated on satellite based assessment of defoliation on Norway spruce. Using imagery from 1985 and 1989 covering an area in southwestern Sweden, the Landsat TM sensitivity to light and moderate defoliation was determined. The utilization of satellite data for assessment of moderate forest decline is in most cases complicated by factors like terrain conditions and variations in age, density and species composition. Studies of the spectral contributions from these factors gave limits for how much they can be allowed to vary, yet preserving a capability to estimate defoliation. Employing slope/aspect data from the digital elevation model and forest stand data digitized forest maps, a model that accounted for the disturbing factors were developed.

The research directed towards eutrophication effects in coastal waters was limited in 1990–1991. However, The earlier developed model for detection of chlorophyll *a* was verified and evaluated. The problems connected to detection of chlorophyll *a* in the presence of suspended sediment was further investigated and a method to reduce the ambiguity of assessments in such areas was developed.

Plans for 1992 and 1993

The intention is to develop the technology in spruce defoliation assessment for operative application in larger areas. This involves methods for

standwise extraction of data from the satellite images, the elevation model and the forest maps, and in the last step a standwise defoliation estimation.

The methods for detection of chlorophyll *a* and other water quality parameters in coastal waters will be further developed and operatively used in the eutrophication-oriented projects in progress at the institute.

Remote Sensing Applications Oceanography/Hydrology, Norrköping

Address: Swedish Meteorological and Hydrological Institute, S-601 76 Norrköping, Sweden

Mr Thomas Thompson
Mr Bertil Håkansson

The programme of the group is focused on Research and Development directed towards operational use within Marine Meteorology, Oceanography and Hydrology. Special emphasize is placed on development of daylight and weather independent methods for sea ice surveillance.

Activities during 1990 and 1991

Improvements of methods for the use of NOAA-AVHRR data

AVHRR data are used operationally at SMHI within the marine Forecasting Services and various marine projects. Continuous work is ongoing to develop new and adjust existing methods for retrieving various geophysical variables. Much effort has been placed on retrieving quantitatively sea ice information and sea surface temperatures. These products are used for sea ice mapping and forecasts as well as for monitoring of water mass distribution, surface currents and some river outlets in the Baltic Sea area.

Some effort has also been placed on improving methods for interpretation and use of AVHRR data in arctic regions, among others have AVHRR data been received and used onboard a Swedish icebreaker during an International Arctic Ocean Expedition in1991.

Systems for digital transmission of image data from SMHI to icebreakers and other users have also been developed.

During the Gulf of Bothnia Year 1991/92 AVHRR data have been collected and will be used for description of ocean processes such as upwelling, surface currents and water mass analysis. Large amounts of in situ data has been collected during this year of intensive measurements.

Preparations for ERS-1: Use of active microwave data for sea ice mapping

The data from the field experiment BEPERS-88, carried out in the Gulf of Bothnia in March 1988, has been processed and analysed and used for the preparation and planning of BEERS-92 (Baltic Experiment for ERS-1). The BDDN system for near real time reception of full resolution SAR images from ESA ground stations (Kiruna and Fucino) was installed at SMHI late 1991.

Procedures have been developed for image preparation and transmission from SMHI to icebreakers via the Nordic Mobile Telephone system (NMT). This will permit SAR images to be transmitted in near real time to field experiment groups during BEERS-92 and benefit the ERS-1 Calibration/Validation programme.

The system is also necessary for the Applications Demonstration programme in which Swedish icebreakers will take part.

Mapping of chlorophyll concentrations in Skagerrak, Kattegatt and the Baltic Sea using LANDSAT TM data

To test the possibility to use LANDSAT TM data for retrieving chlorophyll content mainly in connection with simultaneous in situ data in typical coastal sea areas. The work has been concentrated on field investigations to obtain the proper data set. Some scenes have also been studied using empirical relationships with promising results.

Mapping of concentrations and spread of suspended material from river outlets into the sea

Some rivers along the Swedish and Norwegian coasts transport materials and pollutions to the sea especially during high runoff conditions. This project is aimed at determining the total suspended matter using NOAA -AVHRR and LANDSAT data in order to map the river plume extensions in the estuarie in connnection with the plumes dependence on wind and large scale offshore currents.

Mapping of snow cover in Swedish mountain areas with AVHRR and LANDSAT data

Run-off models have been used for many years to optimize the generation of electric power.

Starting from 1990 automatically classed AVHRR data have been used to map the snow cover during the melt period. The areal snow cover is determined by counting the pixels classed as snow within each drainage basin.

Mapping of land use from LANDSAT data

Investigations have been made of the leakage of nutrients from single as well as areal sources into streams and rivers. Classification of the actual land use is critical for the inputs to the numerical models used. LANDSAT TM data proved to provide the most reliable and up-to-data information compared with traditional maps.

Determination of volumes in water reservoirs

LANDSAT TM data have been used to determine the area of water reservoirs at different water levels. Methods to determine the volume of the reservoirs by use of water level and area cover information have been testes.

Plans for 1992 and onward

Developments of methods for better use of AVHRR data as well as the integration of various sources of information for sea ice mapping and sea surface temperature will continue. The system for real time transmission of image data to icebreakers will become fully operational.

The preparations for ERS-1 will continue and an extensive field programme will be carried out during the ERS-1 "ice orbit" in January, February and March 1992. The programme will include both a calibration/validation and an applications demonstration phase in which the operational sea ice service of SMHI as well as ships and icebreakers operating in the Gulf of Bothnia and Baltic sea will participate. The field programme will be followed by an extensive processing and evaluation period. The field programme will continued on a reduced scale during the winter 1992/93. During the ERS-1 "ice orbit" in 1994 the plans are to carry out an extensive applications demonstration programme of a more operational nature.

The group has been participating actively in an international field experiment (SKAGEX) in the Skagerrak area carried out during spring/summer 1990. Both AVHRR, LANDSAT and aircraft data have been used during the experiment and in the following evaluation.

The activities directed towards mapping of ocean parameters such as chlorophyll, algea blooms, suspended material, pollutants will be continued.

On the hydrological side work will continue on snow, lake/river ice mapping and land use coupled to run off and pollution studies. Studies on area and volume mapping of electric power dams will continue.

National Defence Research Establishment (FOA), Linköping

Address: Department of Information Technology, Box 1165, S-581 11 Linköping, Sweden

Mr O Dahlman
Dr T Orhaug

This department is engaged in applied research in the field of information technology for defence purposes. A small part of ongoing projects has been sponsored by the Swedish National Space Board. Other projects have potential interest for applications in remote sensing. Furthermore, in a program sponsored by the Swedish Ministry for Foreign Affairs, activities are also related to applications of satellite imageries and control of space activities.

Ongoing activities

Computer vision

Projects in image processing, computer vision and image understanding focus on using sensors with high spatial resolution and/or using multisensor systems for data acquisition:

Multisensor data processing:
- matching in digital imagery: a method using hierarchical chamfer techniques has been developed to match images either to maps or to other images (space applications: satellite images, photographic astronomy)
- model-based image analysis: investigations of 3D object representation, hierarchical structures, and control mechanisms (space applications: research on galaxies)
- target detection using evidential reasoning: study of target detection by electro-optical sensors for complex scenes (space applications: photographic astronomy)

Digital geometry:
- investigation of the consequences of using digital, rather than analog, image data, both in the spatial and radiometric domain (space applications: photographic astronomy)

Multisensor data fusion:
- problems of control mechanisms and representations of model knowledge in multisensor systems
- a pilot system incorporating knowledge-based techniques has been developed

Geographical Information Systems (GIS)

GIS projects addressing both applications of GIS systems in various fields and the problem of using digital map representations for spatial reasoning:

Path planning:
- includes the development of a heuristic technique including rule-based inference engine and a graph search/constructive process (space applications: path planning for vehicles on celestial bodies)

Landmark navigation:
- FOA participation in an industrial project concerning the development of a GIS (space applications: navigation on celestial bodies)

Space technology

Projects supported by the Swedish Ministry for Foreign Affairs for technical/scientific assistance to the Ministry's international work on disarmament and arms control:

Space security:
- the controling of space objects and space activities
- the possibilites of monitoring the existence of space objects and their orbital parameters
- the prospects of verifying space weapons treaties
- the space debris problem

Space technology usage:
- in military operations (tactical and strategical)
- in future space weapons
- in conflicts/crises monitoring
- in military and disarmament treaties verification

Nuclear test ban monitoring:
- possibilities of using Landsat and SPOT satellite imageries to detect preparations of underground nuclear explosions are investigated

Simulation of satellite imageries:
- as part of the Swedish project for a peace-keeping satellite (project Tellus) simulations of digital imageries has been made in order to investigate the information content in such imageries having different spatial resolution

COMSENS
- a proposed communication system based on small light-weight satellites in polar orbits for data exchange in arms control and in environmental monitoring

Synthetic Aperture Radar (SAR)

Digital processing and analysis of SAR data started in 1983 with partial funding from the Swedish National Space Board. After an extension of the original three-year project this work was completed in 1990. Methods and facilities have been established for flexible digital image generation from raw data from SAR and experience has been gained in the interpretation of SAR data, as a preparation for the European satellite ERS-1 which was launched in July 1991. The early emphasis of the work was on the processing and use of SAR data from the US satellite Seasat.

SAR activities continue at FOA in several ways. The major current SAR research effort is the CARABAS project. CARABAS (Coherent All RAdio BAnd Sensing) is a new principle for airborne SAR, based on broadband radio frequency radiation, 10-100 MHz. A demonstration system has been developed and the first flights have been carried out.

Another SAR effort, funded by the Swedish National Space Board and summarized here, is in progress in co-operation with Chalmers University of Technology (CUT), the Swedish Space Corporation (SSC), and the Swedish Meteorological and Hydrological Institute (SMHI) for the purpose of preparing for and carrying out the experiment BEERS-92 using SAR data on the ice characteristics in the Gulf of Bothnia to be obtained in January to March 1992 by the ERS-1 satellite. The work at FOA is part of a larger four-year research project called "Storprojekt ERS-1" (Main project ERS-1), which was initiated in 1989 by the Swedish National Space Board and its working group AGERS. The main purpose of the FOA effort is to provide support to the SMHI in its preparations for BEERS-92.

The BEERS-92 experiment comprises a calibration and validation program with extensive ice-truth measurements and a demonstration program focused on the use of SAR data in the SMHI ice service. The purpose of BEERS-92 is to improve and verify techniques for ice classification from SAR images and to test and demonstrate how SAR data may be utilized to improve operational ice service for shipping and ice breaking. BEERS-92 is a collaborative effort under SMHI leadership with international participation, in particular by Finnish groups. Useful experiences in this field were gained already in March 1988 when BEPERS-88, a similar two-week collaborative experiment using data from airborne SAR, was carried out (Bothnian Experiment in Preparation for ERS-1).

Plans for the future

- Further studies on space security issues and space technology usage.
- Investigation of information content in SPOT imagery concerning military activities in connection with the Gulf war.
- Continuation of the BEERS experiments with ERS-1 data.
- Further flight tests to evaluate the CARABAS system.

Space Application Programmes

Remote Sensing of Earth Resources and Environment

Sweden is a participant in the French SPOT programme and in ESA's Earth Observation programme. In addition, over the past decade, massive investments have been made in the Kiruna region, in the far north of Sweden, in the ground infrastructure necessary to support remote sensing satellite systems.

At Esrange, reception, processing, archiving, and distribution of Landsat, MOS and JERS-1 data is carried out under contract to ESA, which also operates a major facility for ERS-1 at Salmijärvi near Esrange. In addition, one of the two principal ground stations in the SPOT system is located in Kiruna.

These various facilities form the basis for the major portion of the national remote sensing programme. In particular, the commercial company SSC Satellitbild has been set up in Kiruna to sell image and map data products on the world market. Satellitbild is a subsidiary of Swedish Space Corporation (SSC).

Considerable efforts are also made to capitalize on these investments for Sweden's domestic needs. Several projects are being carried out in cooperation with forestry companies. The National Land Survey is investigating the possibility of updating its topographic maps with greater frequency using SPOT data. SSC has produced a vegetation map of the entire country for the telecommunications and defense authorities, using Landsat data. A programme to monitor environmental parameters has been started in cooperation with the Swedish Environmental Protection Agency.

Research in cooperation with the Swedish International Development Agency (SIDA) is aimed at supporting development programmes in the third world.

Data from ERS-1 are being used for sea ice monitoring. Support was given to the Swedish icebreaker Oden, which reached the North Pole in 1991. A field campaign in the Baltic Sea took place in 1992.

The third generation of the airborne surveillance system developed by SSC for the Swedish Coast Guard is fully operational. It enjoys continuing commercial success on the world market.

Meteorology

Cloud cover photographs and other meteorological data from EUMETSAT, US and CIS weather satellites were received regularly by the HRPT

and APT stations of the Swedish Weather Services and were used in weather forecasting.

A project concerning the establishment of short term weather forecasting and regional weather service based on advanced space and remote sensing techniques, including weather radar, solar, microwave radiometry and weather satellites, has entered into an operational phase.

Development of the operational use of advanced digital image analysis of polar weather satellite data is going on. A microwave radiometer for sounding of temperature and humidity of the atmosphere is developed for operational use.

Communications

Sweden took part in the communications programmes of ESA such as the advanced systems and technology programme (ASTP), the payload and spacecraft development and experiments programme (PSDE) and the data relay satellite (DRS) preparatory programme.

Tele-X is a telecommunications satellite programme for the Nordic countries managed by the Swedish Space Corporation on behalf of the Nordic Satellite Corporation (NSAB). Tele-X was launched in April 1989 and provides the following services:
- high-speed digital data communications for both interoffice links and wideband services such as image transmission
- television direct broadcasting to home receivers

Navigation

Satellite navigation equipment is in routine use on Swedish merchant vessels using Transit-type satellites.

Other Programmes

Sweden takes part in the ESA programme for receiving, preprocessing, archiving and distribution of images from remote sensing satellites (Earthnet). The Swedish Space Corporation is the National Point of Contact (NPOC), and its ground station at Esrange, Kiruna, forms part of the system.

SSC Satellitbild is a member of the EURIMAGE consortium, which markets satellite data on behalf of ESA/Earthnet.

Esrange

Esrange is a Swedish space research range situated north of the Arctic Circle close to the town of Kiruna at a latitude of about 68° N. The base is managed by the Swedish Space Corporation.

Space research activities are carried out at Esrange as an ESA special project with Germany, France, Switzerland, Norway and Sweden. Due to the geographical location studies of the aurora and other high latitude phenomena are of particular interest.

The land recovery possibility makes Esrange very suitable for all sounding rocket experiments needing recovery, for instance microgravity research. Payloads are normally recovered within an hour from launch.

Esrange has the capacity to launch most types of sounding rockets including high performance vehicles. Six permanent launchers make the launching of most types of sounding rockets possible. Examples: Nike, Terrier and Taurus combinations, Black Brant, Skua, Petrel, Skylark and Aries. By using a guidance system it is possible to launch rockets at Esrange to altitudes of more than 500 km. An attitude control system (SPINRAC) is developed for rockets reaching altitudes of 800-1 000 km. The range also has long experience of releasing scientific balloons and has during recent years developed a European ozon research centre.

Esrange is also used in various satellite projects. A number of ground segments for the support of national and international spacecraft programmes are today in operation or under development.

A facility for the reception, recording, filing, processing and dissemination of Remote Sensing Satellite data was esablished at Esrange in 1978. The station was originally used for spacecraft in the Landsat series and operated within the framework of the European Space Agency's Earthnet programme. The station has been extended to handle data from both remote sensing and scientific satellites and has several independent antennas and processing systems.

A satellite control station of universal design performs TT&C operations on orbiting satellites. Esrange operates and monitors satellites on behalf of customers or offers use of the station in a transparent mode where remote customers are connected to the station for real time access to their satellites.

The ground control station for Tele-X is also located at Esrange.

At Salmijärvi, in the vicinity of Esrange, ESA has established a ground station for ERS-1, which is operated by SSC.

A ground control station for the Japanese Earth Resource Satellite JERS in cooperation with NASDA was inaugerated in April 1992.

Space-related Facilities and Installations

During 1990 and 1991 Sweden took part in the work of the EISCAT Scientific Association. The Association has installed a multistatic incoherent scatter facility in the auroral zone, comprising a system of stations at Tromsø (Norway), Kiruna (Sweden) and Sodankylä (Finland).

The Onsala Space Observatory, operates radiotelescopes, principally for radioastronomical observations. The newest telescope has a radome-enclosed 20 m diameter reflector with very high surface accuracy for work at millimeter wavelengths.

Sweden operates major ground facilities in support of remote sensing satellites, as noted in previous sections.

A large number of image processing systems are available at different scientific and operational institutions in Sweden.

SSC Satellitbild in Kiruna has extensive computer resources for preprocessing, precision correcting, and analyzing satellite image data. There is also a well equipped photographic laboratory.

A joint Scandinavian Intelsat earth station is located at Tanum on the west coast of Sweden.

A joint Scandinavian earth station for the European Communication Satellite System (ECS) is located near Stockholm.

Optical and radio tracking of satellites for geodetic purposes is performed by the Geodetic Institute at the Uppsala University.

Publications during 1990 and 1991

Swedish Institute of Space Physics – Kiruna Division

Anasuya, A., D. Rees, and Å. Steen, Seasonal and solar cycle variations in high latitude thermospheric winds, accepted for publication in Geophys. Res. Lett., 1991.

Andersen, T., E. Friis-Christensen, H. Nevanlinna, H. Opgenoorth, H. Ranta, and Å. Steen, Nordic Geophysical Data Base (NGDB), in "Proceedings of the meeting of the Nordic Society for Space Research", Norwegian Space Centre Report, (91)2, 1991.

Aparicio, B., B. Thelin, and R. Lundin, The polar cusp from a particle point of view: A statistical study based on Viking data, J. Geophys. Res., 96, 14023, 1991.

Austin, J.B., J.S. Murphree, and J. Woch, Polar arcs: new results from Viking UV images, submitted to J. Geophys. Res., 1991.

Barabash, S.V., E. Dubinin, N. Pissarenko, R. Lundin, and C.T. Russel, Picked-up protons near Mars: Phobos observations, Geophys. Res. Lett., 18, 1805, 1991.

Breus, T.K., A.M. Krymskii, R. Lundin, E.M. Dubinin, J.G. Luhmann, E.G. Eroshenko, S.V. Barabash, V. Ya. Minitskii, N.F. Pissarenko, and K.A. Stayshkin, The solar wind interaction with Mars: Consideration of Phobos-2 mission observations of the ion composition boundary on the dayside, J. Geophys. Res., 96, 11165, 1991.

Brüning, K., L.P. Block, G.T. Marklund, L. Eliasson, R. Pottelette, J.S. Murphree, T.A. Potemra, and S. Perraut, Viking observations above a postnoon aurora, J. Geophys. Res., 95, 6039–6049, 1990.

Brändström, U., and Å. Steen, ALIS station architecture, submitted to Proceedings from NSSR-meeting at Mön, Denmark, 1991.

Chmyrev, V.M., V.A. Marchenko, O.A. Pokhotelov, L. Stenflo, A.V. Streltsov, and Å. Steen, Vortex structures in the ionosphere and the magnetosphere of the Earth, Planet. Space Sci., 39, 1025–1030, 1991.

Collis, P.N., and I. Häggström, High-latitude ionospheric response to a geomagnetic sudden commencement, J. Atmos. Terr. Phys., 53, 241–248, 1991.

Collis, P.N., I. Häggström, K. Kaila, and M.T. Rietveld, EISCAT radar observations of enhanced incoherent scatter spectra: Their relation to red aurora and field-aligned currents, Geophys. Res. Lett., 18, 1031–1034, 1991.

Dubinin, E.M., R. Lundin, N. Pissarenko, S.V. Barabash, A.V. Zakharov, H. Koskinen, K. Schwingenshuh, and E.G. Eroshenko, Indirect evidences for a gas/dust torus along the Phobos orbit, Geophys. Res. Lett., 17, 861, 1990.

Dubinin, E.M., N. Pissarenko, S.V. Barabash, A.V. Zakharov, R. Lundin, H. Koskinen, K. Schwingenshuh, and E.G. Eroshenko, Tails of Phobos and Deimos in the solar wind and in the Martian magnetosphere, Planet. Space Science, 39, 113, 1991.

Dubinin, E.M., N. Pissarenko, S.V. Barabash, A.V. Zakharov, R. Lundin, H. Koskinen, K. Schwingenshuh, and E.G. Eroshenko, Plasma and magnetic field effects associated with Phobos and Deimos tori, Planet. Space Science, 39, 123, 1991.

Dubinin, E.M., R. Lundin, W. Riedler, K. Schwingenshuh, J.G. Luhmann, C.T. Russel, and L.H. Brace, Comparison of observed plasma and magnetic field

structures in the wakes of Mars and Venus, J. Geophys. Res., 96, 11189, 1991.
Hilgers, A., A. Roux, and R. Lundin, Characteristics of AKR sources: A statistical description, Geophys. Res. Lett., 18, 1493–1496, 1991.
Hultqvist, B., and C.-G. Fälthammar (Eds), Magnetospheric Physics: Achievements and Prospects, Plenum Press, 1990.
Hultqvist, B., Achievements of magnetospheric research, in "Magnetospheric Physics: Achievements and Prospects" Eds B. Hultqvist and C.-G. Fälthammar, Plenum Press, 21–39, 1990.
Hultqvist, B., Presentation of prof J. A. Van Allen as Crafoord Prize Winner, in "Magnetospheric Physics: Achievements and Prospects" Eds B. Hultqvist and C.-G. Fälthammar, Plenum Press, 1–7, 1990.
Hultqvist, B., Rymdforskning i översta Norrland, Thule, Kungl. Skytteanska Samfundet Årsbok 1989, 1990.
Hultqvist, B., The Swedish satellite project Viking, J. Geophys. Res., 95, 5749, 1990.
Hultqvist, B., On the connections between astrophysics and magnetospheric physics, in "Proceedings of the Meeting of the Nordic Society for Space Research", Norwegian Space Centre Report, (91)2, 1991.
Hultqvist, B., Extraction of ionospheric plasma by magnetospheric processes, J. Atmos. Terr. Phys., 53, 3–15, 1991.
Hultqvist, B., H. Vo, R. Lundin, B. Aparicio, P.-A. Lindqvist, G. Gustafsson, and B. Holback, On the upward acceleration of electrons and ions by low-frequency electric field fluctuations observed by Viking, J. Geophys. Res., 96, 11609–11615, 1991.
Hultqvist, B., On the motion of electrons in the slow electric field fluctuations observed by Viking, J. Geophys. Res., 96, 19513–19519, 1991.
Häggström, I., H.J. Opgenoorth, P.J.S. Williams, G.O.L. Jones, and K. Schlegel, Application of alternating codes for EISCAT observations during ERRRIS, J. Atm. Terr. Phys., 52, 431–438, 1990.
Häggström I., Incoherent scatter studies of upper atmosphere dynamics and coding technique, (PhD thesis), IRF Scientific Report 204, September 1990.
Häggström I., The use of alternating codes for incoherent scatter, in "Proceedings of SNRV-RVK", 1990.
Häggström I., and P.N. Collis, Ion composition changes during F-region density depletions in the presence of electric fields at auroral latitudes, J. Atmos. Terr. Phys., 52, 519–529, 1990.
Johansson, H., Station software for ALIS, IRF Technical Report 036, August 1991.
Jones, B., P.J.S. Williams, K. Schlegel, T. Robinson, and I. Häggström, Interpretation of enhanced electron temperatures measured in the auroral E-region during the ERRRIS campaign, Ann. Geophysicae, 9, 55–59, 1991.
Keppler, E., M. André, J.B. Blake, A. Korth, J. Quenby, G. Umlauft, and J. Woch, The ULYSSES energetic particle composition experiment EPAC, accepted for publication in Astron. Astrophys., 1991.
Keppler, E., M. André, J.B. Blake, A. Korth, K. Naidu, J. Quenby, and J. Woch, The ULYSSES energetic particle composition experiment EPAC and the March 1991 solar events, submitted to Astron. Astrophys., 1991.
Kirkwood, S., and L. Eliasson, Energetic particle precipitation in the substorm growth phase measured by EISCAT and Viking, J. Geophys. Res., 95, 6025–6037, 1990.
Kirkwood, S. Electrodynamics of the auroral E region, (PhD thesis), IRF Scientific Report 205, October 1990.

Kirkwood, S., Anomalous ion layers in the high-latitude winter E-region, Geophys. Res. Lett., 18, 1189–1192, 1991.
Kirkwood, S., and U. von Zahn, On the role of auroral electric fields in the formation of low altitude sporadic-E and sudden sodium layers, J. Atmos. Terr. Phys., 53, 389–407, 1991.
Kirkwood, S., T. Blix, U.-P. Hoppe, I. Häggström, U. von Zahn, Measurements from the EISCAT radar during DYANA, Proc. Tenth ESA/PAC Symposium, Mandelieu-Cannes, France, ESA SP-317, 413–418, 1991.
Kirkwood, S., and U. von Zahn, The role of magnetospheric electric fields in producing auroral zone thin layers, Adv. Space Res., in press 1991.
Kirkwood, S., and N. Björnå, Electron temperatures determined by tristatic plasmaline observations with the EISCAT UHF incoherent scatter radar, submitted to Geophys. Res. Lett., 1991.
Kirkwood, S., Modelling the undisturbed high-latitude E-region, Adv. Space Res., 12, (6)329-(6)332, 1992.
Koskinen, H., R. Lundin, and B. Holback, On the plasma environment of solitary waves and weak double layers, J. Geophys. Res., 95, 5921–5929, 1990.
Kremser G. and R. Lundin, Average distributions of energetic particles in the midlatitude cusp/cleft region observed by Viking, J. Geophys. Res., 95, 5753–5766, 1990.
Leyser, T.B., B. Thidé, H. Derblom, Å. Hedberg, B. Lundborg, P. Stubbe, and, H. Kopka, Dependence of stimulated electromagnetic emission on the ionosphere and pump wave, J. Geophys. Res., 95, 17233–17244, 1990.
Lilensten, J., D. Fontaine, W. Kofman, L. Eliasson, C. Lathuillere, and E.S. Oran, Electron energy budget in the high-latitude ionosphere during Viking/EISCAT coordinated measurements, J. Geophys. Res., 95, 6081–6092, 1990.
Leyser, T.B., Parametric interaction between upper hybrid and lower hybrid waves in heating experiments, Geophys. Res. Lett., 18, 408–411, 1991.
Leyser, T.B., B. Thidé, S. Goodman, M. Waldenvik, E. Veszelei, S.M. Grach, A.N. Karashtin, G.P. Komrakov, and D.S. Kotik, Narrow cyclotron harmonic absorption resonances of stimulated electromagnetic emission in the ionosphere, submitted to Phys. Rev. Lett., 1991.
Lundin, R., A. Zakharov, R. Pellinen, S.W. Barabasj, H. Borg, E.M. Dubinin, B. Hultqvist, H. Koskinen, I. Liede, and N. Pissarenko, ASPERA/Phobos measurements of the ion outflow from the Martian ionosphere, Geophys. Res. Lett., 17, 873, 1990.
Lundin, R., A. Zakharov, R. Pellinen, H. Borg, B. Hultqvist, N. Pissarenko, E.M. Dubinin, S.W. Barabasj, I. Liede, and H. Koskinen, Plasma composition measurements of the Martian magnetosphere morphology, Geophys. Res. Lett., 17, 877, 1990.
Lundin, R., G. Gustafsson, A.I. Eriksson, G. Marklund, On the importance of high-latitude low-frequency electric fluctuations for the escape of ionospheric ions, J. Geophys. Res., 95, 5905–5919, 1990.
Lundin, R., Något om vad Phobosmissionen lärt oss, Astronomisk Årsbok 1990, 78–84, 1990.
Lundin, R., and E.M. Dubinin, Phobos-2 results on the ionospheric plasma escape from Mars, Adv. Space Res., in press 1991.
Lundin, R., I. Sandahl, J. Woch, and R. Elphinstone, The contribution of the boundary layer EMF to magnetospheric substorms, in "Magnetospheric Substorms", Geophysical Monograph 64, Eds. J.R. Kan, T.A. Potemra, S. Kokubun, and T. Iijima, American Geophysical Union, 355–373, 1991.
Lundin, R., E.M. Dubinin, H. Koskinen, O. Norberg, N. Pissarenko, and S.V.

Barabash, On the momentum transfer of the solar wind to the Martian topside ionosphere, Geophys. Res. Lett., 18, 1059–1062, 1991.
Lundin, R., and L. Eliasson, Auroral energization processes, Ann.Geophysicae, 9, 202–223, 1991.
Lundin, R., L. Eliasson, and J.S. Murphree, The quiet-time aurora and the magnetospheric configuration, In "Auroral Physics" Eds. C.-I. Meng, M.J. Rycroft and L.A. Frank, Cambridge UP, 177–193, 1991.
Lundin, R., J. Woch, and M. Yamauchi, The present understanding of the cusp, submitted to Proceedings of the ESA CLUSTER Workshop, 1991.
Malingre, M., R. Pottelette, N. Dubouloz, P.-A. Lindqvist, G. Holmgren, and B. Aparicio, Sporadic electromagnetic emissions in the AKR frequency range associated with electrostatic plasma turbulence, submitted to J. Geophys. Res., 1991.
Marklund, G.T., L.G. Blomberg, J.S. Murphree, R.D. Elphinstone, L.J. Zanetti, R.E. Erlandson, I. Sandahl, O. de la Beaujardière, H. Opgenoorth, and F.J. Rich, On the electrodynamical state of the auroral ionosphere during northward interplanetary magnetic field: A transpolar arc case study, J. Geophys. Res., 96, 9567–9578, 1991.
Mishin, V.M., A.D. Bazarzhapov, T.I. Saifudinova, S.B. Lunyushkin, D.Sh. Shirapov, J. Woch, L. Eliasson, H. Opgenoorth, and J.S. Murphree, Different methods to determine the polar cap area, submitted to J. Geomagn. Geoelectr., 1991.
Mishin, V.M., L.P. Block, A.D. Bazarzhapov, T.I. Saifudinova, S.B. Lunyushkin, D.Sh. Shirapov, J. Woch, L. Eliasson, G.T. Marklund, L.G. Blomberg, and H. Opgenoorth, A study of the CDAW-9C substorm and the auroral surge formation, May 3, 1986, submitted to J. Geophys. Res., 1991.
Mitchell, D.G., M.J. Engebretson, D.J. Williams, C.A. Cattell, and R. Lundin, Pc 5 pulsations in the outer dawn magnetosphere seen by ISEE 1 and 2, J. Geophys. Res., 95, 967, 1990.
Norberg, O., and L. Eliasson, The hot plasma spectrometers on Freja, ESA SP-317, 1991.
Opgenoorth, H.J., I. Häggström, P.J.S. Williams, and G.O.L. Jones, Strong electric fields and associated E-region temperature elevations in the vicinity of auroral arcs, J. Atm. Terr. Phys., 52, 449–458, 1990.
Pellinen-Wannberg, A., I. Sandahl, G. Wannberg, H. Opgenoorth, F. S. Söraas, and J.S. Murphree, EISCAT observations on plasma drifts connected with the Aureld-VIP rocket and the Viking satellite, J. Geophys. Res. 95, 6073–6080, 1990.
Pfaff, R.F., J. Sahr, J.F. Providakes, W.E. Swartz, D.T. Farley, P.M. Kintner, I. Häggström, Å. Hedberg, H. Opgenoorth, G. Holmgren, A. McNamara, D. Wallis, B. Whalen, A. Yau, S. Watanabe, F. Creutzberg, P. Williams, E. Nielsen, K. Schlegel, and T.R. Robinson, The E-Region Rocket/Radar Instability Study (ERRRIS): Scientific objectives and campaign overview, submitted to J. Atmos. Terr. Phys., 1991.
Potemra, T.A., R.E. Erlandson, L.J. Zanetti, R.L. Arnoldy, J. Woch, and E. Friis-Christensen, The dynamic cusp, accepted for publication in J. Geophys. Res., 1991.
Pottelette, R., M. Malingre, N. Dubouloz, B. Aparicio, R. Lundin, G. Holmgren, and G. Marklund, High-frequency waves in the cusp/cleft regions, J. Geophys. Res., 5957–5971, 1990.
Roux, A., S. Perraut, P. Robert, A. Morane, A. Pedersen, A. Korth, G. Kremser, B. Aparicio, D. Rodgers, and R. Pellinen, Plasma sheet instability related to

the westward travelling surge, J. Geophys. Res., 96, 17697–17714, 1991.
Sandahl, I., L. Eliasson, A. Pellinen-Wannberg, G. Rostoker, L.P. Block, R.E. Erlandson, E. Friis-Christensen, B. Jacobsen, H. Lühr, and J.S. Murphree, Distribution of auroral precipitation at midnight during a magnetic storm, J. Geophys. Res., 95, 6051–6072, 1990.
Sandahl, I., and P.-A. Lindqvist, Electron populations above the nightside auroral oval during magnetic quiet times, Planet. Space Sci., 38, 1031–1049, 1990.
Sandahl, I., Norrsken – budbärare från rymden, IRF Scientific Report 207, February 1991.
Sergeev, V.A., B. Aparicio, S. Perraut, M.V. Malkov, and R.J. Pellinen, Structure of the inner plasma sheet at midnight during steady magnetospheric convection, Planet. Space Sci., 39, 1083–1096, 1991.
Shepherd, G.G., Å. Steen, and J.S. Murphree, Auroral boundary dynamics observed simultaneously from the Viking spacecraft and from the ground, J. Geophys. Res., 95, 5845–5865, 1990.
Steen, Å., U. Brändström, and K. Kaila, A scientific and technical description of ALIS, in "Proceedings of the Meeting of the Nordic Society for Space Research", Norwegian Space Centre Report, (91)2, 1991.
Steen, Å., and G. Witt (Eds), Proceedings of the 17th Annual Meeting on the Studies of the Upper Atmosphere by Optical Methods, IRF Scientific Report 206, April 1991.
The Freja science team, The Freja scientific satellite, Ed.Mats André (190 pages), Swedish Institute of Space Physics, Kiruna, 1991.
Thelin B., and R. Lundin, Upflowing ionospheric ions and electrons in the cusp-cleft region, J. Geomag. Geoelectr., 42, 753, 1990.
Thelin, B., B. Aparicio, and R. Lundin, Observations of upflowing ionospheric ions in the mid-altitude cusp/cleft region with the Viking satellite, J. Geophys. Res., 95, 5931–5939, 1990.
Thelin, B., R. Lundin, and B. Aparicio, Correlations between ion conics and electron beams observed by the Viking satellite in the cusp-cleft region, Geophys. Res. Lett., 18, 1679–1682, 1991.
Thidé, B., F.T. Djuth, H.M. Ierkic, and T.B. Leyser, Evolution of Langmuir turbulence and stimulated electromagnetic emissions excited with a 3-MHz pump wave at Arecibo, submitted to J. Geophys. Res., 1991.
Vogelsang, H., H. Woelker, H. Lühr, J. Woch, T. Bösinger, and P.-A. Lindqvist, An ionospheric travelling convection vortex event observed by ground-magnetometers and by Viking, submitted to Geophys. Res. Lett., 1991.
Wahlund, J.E., H.J. Opgenoorth, I. Häggström, K.J. Winser, and G.O.L. Jones, EISCAT observations of topside ionospheric ion outflows during auroral activity: Revisited, accepted for publication in J. Geophys. Res., 1991.
Williams, P.J.S., G.O.L. Jones, B. Jones, H.J. Opgenoorth, and I. Häggström, High resolution measurements of magnetospheric electric fields, J. Atm. Terr. Phys., 52, 439–448, 1990.
Woch, J., G. Kremser, and A. Korth, A comprehensive investigation of compressional ULF waves observed in the ring current, J. Geophys. Res., 95, 15113 - 15132, 1990.
Woch J., and R. Lundin, Temporal magnetosheath plasma injection observed with Viking: A case study, Ann. Geophysicae, 9, 133–142, 1991.
Woch, J., and R. Lundin, Signatures of transient boundary layer processes observed with Viking, accepted for publication in J. Geophys. Res., 1991.
Woch, J., and R. Lundin, Magnetosheath plasma precipitation in the polar cusp

and its control by the interplanetary magnetic field, accepted for publication in J. Geophys. Res., 1991.
Yamauchi, M., R. Lundin, and J. Woch, The IMF B_y effects on large-scale field-aligned currents near local noon: Contributions from cusp part and non-cusp part, submitted to Geophys. Res. Lett., 1991.

Swedish Institute of Space Physics – Umeå Division

André, M., G.B. Crew, W.K. Peterson, A.M. Persoon, C.J. Pollock and M.J. Engebretson, Heating of ion conics in the cusp/cleft, in "SPI Conference Proceedings and Reprint Series", Scientific Publishers, Cambridge Massachusetts, p 203, 1990.
André, M., G.B. Crew, W.K. Peterson, A.M. Persoon, C.J. Pollock and M.J. Engebretson, Ion heating by broadband low-frequency waves in the cusp/cleft, J. Geophys. Res., 95, 20809–20823, 1990.
Ball, L., and M. André, Heating of O+ ions in the cusp/cleft: double-cyclotron absorbtion versus cyclotron resonance, J. Geopys. Res., 96, 1429–1437, 1991.
Ball, L., M. André, and J.R. Johnson, Wave observations and their relation to "nonresonant" ion heating in a "weakly turbulent" plasma model, Ann. Geophysicae, 9, 37–41, 1991.
Ball, L., and M. André, What parts of broadband spectra are responsible for ion conic production?, Geophys. Res. Lett., 18, 1683–1686, 1991.
Biro, T., and K. Rönnmark, Phase space description of plasma waves: 1. Linear theory, submitted to J. Plasma Phys., 1991.
Gustafsson, G., M. André, L. Matson and H. Koskinen, On waves below the local proton gyrofrequency in auroral acceleration regions, J. Geophys. Res., 95, 5889–5904, 1990.
Keppler, E., M. André, J.B. Blake, A. Korth, J. Quenby, G. Umlauft, and J. Woch, The ULYSSES energetic particle composition experiment EPAC, accepted for publication in Astron. Astrophys., 1991.
Keppler, E., M. André, J.B. Blake, A. Korth, K. Naidu, J. Quenby, and J. Woch, The ULYSSES energetic particle composition experiment EPAC and the March 1991 solar events, submitted to Astron. Astrophys., 1991.
Louarn, P., A. Roux, H. de Feraudy, D. LeQuéau, M. André, and L. Matson, Trapped electrons as a free energy source for the AKR, J. Geophys. Res., 95, 5983–5995, 1990.
Oscarsson T., and K. Rönnmark, A combined wave distribution function and stability analysis of Viking particle and low-frequency wave data, J. Geophys. Res., 95, 21187–21202, 1990.
Oscarsson, T., and K. Rönnmark, Reply to "Comments on Absolute and Convective Instabilities," accepted for publication in J. Geophys. Res., 1991.
Rönnmark, K., Quantitative methods for waves in space plasmas, Space Sci. Rev., 54, 1–73, 1990.
Rönnmark, K., and M. André, Convection of ion cyclotron waves to ion-heating regions, J. Geophys. Res., 96, 17573–17579, 1991.
Rönnmark, K., Conversion of upper hybrid waves into magnetospheric radiation, submitted to Proceedings of the 3rd International Workshop on Radio Emissions from Planetary Magnetospheres, Graz, Austria, Sep. 2–4, 1991
Rönnmark, K., and T. Biro, Phase space description of plasma waves: 2. Nonlinear theory, submitted to J. Plasma Phys., 1991.
Ungstrup, E., A. Bahnsen, H.K. Wong, M. André, and L. Matson, Energy

source and generation mechanism for auroral kilometric radiation, J. Geophys. Res., 95, 5973–5981, 1990.

Swedish Institute of Space Physics – Uppsala Division

Boström, R., IMPACT – A proposal for Nordic participation, Proc. Nordic Society for Space Research (NSSR), p. 99–104, 1991.

Boström, R., Observations of weak double layers on auroral field lines, to be published in IEEE Trans. Plasma Sci., (paper presented at the Alpbach Workshop on Plasma Experiments in Laboratory and in Space), 1991.

Boström, R., Observations of auroral double layers, to be published in the proceedings of the Cargèse Workshop on Collective Acceleration Processes in Collisionless Plasmas, Editions de Physique, Les Ulis, 1991.

Boström, R., and G. Holmgren, Magnetospheric wave observations and interpretations in Proceedings of the Eighth General Conference of the European Physical Society, Amsterdam, Sept. 1990, edited by J. Kaczér, Prometheus, Prag 1991, p. 845–859.

Dubouloz, N., R. Pottelette, M. Malingre, G. Holmgren and P.-A. Lindqvist, Detailed analysis of broadband electrostatic noise in the dayside auroral zone, J. Geophys. Res., 96, 3565–3579, 1990.

Eliasson, L., G. Holmgren and M. André, Auroral particle acceleration at high latitudes: Viking Results (Abstract), Annales Geophysicae, Special Issue, 249, 1990.

Erlandson, R.E., L.J. Zanetti, T.A. Potemra, L. Block and G. Holmgren, Viking magnetic and electric field observations of Pc 1 waves at high latitudes, J. Geophys. Res., 95, 5941–5955, 1990.

Gustafsson, G., M. André, L. Matson and H. Koskinen, On waves below the local proton gyrofrequency in auroral acceleration regions, J. Geophys. Res., 95, 5889–5904, 1990.

Gustafsson, G., Mapping of the auroral oval to the tail, Proc. of the ESA Cluster Workshop, Longyearbyn, September 1991.

Gustafsson, G., N.E. Papitashvili and V.O. Papitashvili, A revised corrected geomagnetic coordinate system, Proc. of the IAGA Meeting, Vienna, August 1991.

Hilgers, A., The auroral radiating plasma cavities, accepted for publication in Geophys. Res. Lett., 1991.

Hilgers, A., H. de Feraudy, and D. le Quéau, First measurement of AKR polarization inside the sources, accepted for publication in J. Geophys. Res., 1991.

Hilgers, A., B. Holback, G. Holmgren and R. Boström, Probe measurements of low plasma densities with applications to the auroral acceleration region and AKR sources, accepted for publication in J. Geophys. Res., 1991.

Hilgers, A., A. Roux and R. Lundin, Characteristics of AKR sources; A statistical description, Geophys. Res. Lett., 18, 1493–1496, 1991.

Holmgren, G. and P.M. Kintner, Experimental Evidence of Widespread Regions of Small-Scale Plasma Irregularities in the Magnetosphere, J. Geophys. Res., 95, 6015–6023, 1990.

Hultqvist, B., H. Vo, R. Lundin, B. Aparicio, P-A Lindqvist, G. Gustafsson and B. Holback, On the upward acceleration of electrons and ions by low-frequency electric field fluctuations observed by Viking, J. Geophys. Res., 96, 11609–11615, 1991.

Häggström, I., H. Opgenoorth, P.J.S. Williams, G.O.L. Jones and K. Schlegel,

Application of alternating codes for EISCAT observations during the ERRRIS campaign for E-region plasma irregularities, J. Atmos. Terr. Phys., 52, No 6–8, 431–438, 1990.
Koskinen, H.E.J., R. Lundin and B. Holback, On the plasma environment of solitary waves and weak double layers, J. Geophys. Res., 95, 5921–5929, 1990.
Lundin, R., Gustafsson, G., A.I. Eriksson and G. Marklund, On the importance of high altitude low-frequency electric fluctuations for the escape of ionospheric ions, J. Geophys. Res., 95, 5905–5919, 1990.
Maehlum, B.N., W.F. Denig, M. Friedrich, K.M. Torkar, K. Svenes, N.C. Maynard, J. Tröim, G. Holmgren, and W.J. Burke, Plasma disturbances observed in the ionosphere in the vicinity of a highly charged space vehicle, Adv. Space Res., 10, No 7, 125–132, 1990.
Malingre, M., R. Pottelette, N. Dubouloz, P.A. Lindqvist, G. Holmgren and B. Aparicio, Sporadic electromagnetic emissions in the AKR frequency range associated with electrostatic plasma turbulence, submitted for publication in J. Geophys. Res., 1991.
Pellinen-Wannberg, A., I. Sandahl, G. Wannberg, R. Lundin, H.J. Opgenoorth, F. Søraas, and J.S. Murphree, EISCAT observations on plasma drifts connected with the Aureld-VIP rocket and the Viking satellite, J. Geophys. Res., 95, 6073–6080, 1990.
Pottelette, R., M. Malingre, N. Dubouloz, B. Aparicio, R. Lundin, G. Holmgren and G. Marklund, High-frequency waves in the cusp/cleft regions, J. Geophys. Res., 95, 5957–5971, 1990.
Stasiewicz, K., A global model of gyroviscous field line merging at the magnetopause, J. Geophys. Res., 96, p 77–86, 1991.
Stasiewicz, K., Polar cusp topology and position as a function of Interplanetary Magnetic Field and magnetic activity: Comparison of a model with Viking and other observations, J. Geophys. Res., 96, 15789–15800, 1991.
Svenes, K.R., B.N. Maehlum, R.L. Arnoldy, G. Holmgren and F. Søraas, The polar F-region, a neglected region of investigation, Proc. Nordic Society for Space Research (NSSR), p 239–249, 1991.
Svenes, K.R., J. Trøim, B.N. Maehlum, M. Friedrich, K.M. Torkar, G. Holmgren and W.F. Denig, Ram-wake measurements obtained from the ionospheric sounding rocket MAIMIK, Planet. Space Sci., 38, No 5, 653–663, 1990.

Space Physics Group, Department of Plasma Physics of the Alfvén Laboratory, Royal Institute of Technology, Stockholm

Alfvén, H., Cosmology in the Plasma Universe, IEEE Transactions on Plasma Science, *18*, 5, 1990.
Alfvén, H. and Carlqvist, P., Solar Flares and Current Interpretation, Current Contents, *14*, 16, 1990.
Alfvén, H. and Fälthammar, C.-G., Can the Big Bang Survive in the Space Age?, TRITA-EPP-90–02, Royal Institute of Technology, Stockholm, Sweden, 1990.
Axnäs, I. and Brenning, N., Experiments on the Magnetic Field and Neutral Density Limits on CIV Interaction, Adv. Space Res., *10*, 27, 1990.
Axnäs, I., Anomalous Cross-Field Currents in a CIV Laboratory Experiment, Adv. Space Res., *10*, 17, 1990.
Axnäs, I., and Brenning, N., Laboratory Experiments on the Magnetic Field and

Neutral Density Limits on CIV Interaction, Plasma Phys. Contr. Fusion, Vol 33, No 1, 1–27, 1991.

Block, L.P. and Fälthammar, C.-G., The Role of Magnetic-Field Aligned Electric Fields in Auroral Acceleration, J. Geophys. Res., *95*, 5877, 1990.

Block, L. P., and Fälthammar, C.-G., Characteristics of Magnetic-Field Aligned Electric Fields in the Auroral Acceleration Region, pp. 109–118 in *Auroral Physics*, Ed. Meng, C.-I., Rycroft, M.J. and Frank, L.A., Cambridge University Press, 1991.

Blomberg, L. G., Modelling of High-Latitude Ionospheric Electrodynamics, Ph. D. Thesis, Royal Inst. of Technology, Stockholm, 1991.

Blomberg, L., and Bolin, O., Från atmosfären till oändligheten, pp. 82–88 in *Astronomisk Årsbok 1991*, Inova Publishing Company, Stockholm, Sweden, 1990.

Blomberg, L. G., and Marklund, G. T., High-Latitude Convection Patterns for Various Large-Scale Field-Aligned Current Configurations, Geophys. Res. Lett., *18*, 717, 1991.

Blomberg, L.G., and Marklund, G.T., A Numerical Model of Ionospheric Convection
Derived from Field-Aligned Currents and the Corresponding Conductivity, TRITA-EPP-91–03, Royal Institute of Technology, Stockholm, Sweden, 1991.

Bohm, M., Brenning, N. and Fälthammar, C.-G., Dynamic Trapping: Neutralization of Positive Space Charge in a Collisionless Magnetized Plasma, Phys. Rev. Lett., *65*, 859, 1990.

Bohm, M. and Torvén, S., Potential Drops Supported by Ion Density Cavities in the Dynamic Response of a Plasma Diode to an Applied Field, TRITA-EPP-90–03, Royal Institute of Technology, Stockholm, Sweden, 1990.

Bohm, M. and Torvén, S., The Dynamic Response of an Inhomogeneous Plasma Diode to an Applied Electric Field, TRITA-EPP-90–05, Royal Institute of Technology, Stockholm, Sweden, 1990.

Bolin, O., and Petro, A., An Aggressive Alternative Approach, App. 8 in *International Mars Mission,* final report from International Space University Summer Session 1991, Toulouse, France, 1991.

Brenning, N., Fäthammar, C.-G. and Bohm, M., An Extension of the Boltzmann Relation to Collisonfree Magnetized Plasma, TRITA-EPP-90–08, Royal Institute of Technology, Stockholm, Sweden, 1990.

Brenning, N., Fälthammar, C.-G., Haerendel, G., Kelley, M., Marklund, G., Providakes, J., Stenbaek-Nielsen, H.C., Swenson,C., Torbert, R. and Wescott, E.M., Electrodynamic Interaction Between the CRIT I Ionized Ba Cloud and the Ambient Ionosphere, Adv. Space Res., *10*, No. 7, p. 67, 1990.

Brenning, N., Fälthammar, C.-G., Haerendel, G., Kelley, M., Marklund,G., Pfaff, R., Providakes, J., Stenbaek-Nielsen, H.C., Swenson, C., Torbert, R. and Wescott, E.M., Critical Ionization Velocity Interaction in the CRIT I Rocket Experiment, Adv. Space Res., *10*, No. 7, p. 63, 1990.

Brenning, N. and Mendillo, M. (Editors), Activity Experiments/Critical Ionization Velocity, Adv. Space Res., *10*, No. 7. 1990.

Brenning, N., Fälthammar, C.-G., Haerendel, G., Kelley, M., Marklund, G., Pfaff, R., Providakes, J., Stenbaek-Nielsen, H. C., Swenson, C., Torbert, R., and Wescott, E. M., Interpretation of the Electric Fields Measured in an Ionospheric Critical Ionization Velocity Experiment, J. Geophys. Res., Vol. 96, 9719, 1991.

Brenning, N., Providakes, J., Kelley, M., and Swenson, C., Barium Swarm: an Ionospheric AC generator in CRIT I, J. Geophys. Res., Vol. 96, 9735, 1991.

Brüning, K., Block, L.P., Marklund, G.T., Eliasson, L., Pottelette, R., Murphree, J.S., Potemra, T.A. and Perraut, S., Viking Observations above a Postnoon Aurora, J. Geophys. Res., *95*, 6039, 1990.

Carlqvist, P., and Gahm, G., Manifestations of Electric Currents in Molecular Clouds, TRITA-EPP-91–05, Royal Institute of Technology, Stockholm, Sweden, 1991.

Dubouloz, N., Pottelette, R., Malingre, M., Holmgren, G., and Lindqvist, P.-A., Detailed Analysis of Broadband Electrostatic Noise in the Dayside Auroral Zone, J. Geophys. Res., *96*, 3565, 1991.

Erlandson, R.E., Zanetti, L.S., Potemra, T.A., Block, L.P. and Holmgren, G., Viking Magnetic and Electric Field Observations of Pc1 Waves at High Latitudes, J. Geophys. Res., *95*, 5941, 1990.

Fälthammar, C.-G., Electrodynamics of Cosmic Plasmas – Some Basic Aspects of Cosmological Importance, IEEE Trans. Plasma Sci., *18*, 11, 1990.

Fälthammar, C.-G., The Plasma Universe, pp. 9–20 in *Basic Plasma Processes on the Sun*, Ed. E.R. Priest and V. Krishan, International Astronomical Union, 1990.

Fälthammar, C.-G., Exploring the Plasma Universe, internal report 91–103, Royal Inst. of Technology, Dept. of Plasma Physics, Stockholm, Sweden, 1991.

Fälthammar, C.-G., Physics of the Aurora, TRITA-EPP-91–06, Royal Institute of Technology, Stockholm, Sweden, 1991.

Hultqvist, B., Vo, H., Lundin, R., Aparicio, B., Lindqvist, P.-A., Gustafsson, G., and Holback, B., On the Upward Acceleration of Electrons and Ions by Low-Frequency Electric Field Fluctuations Observed by Viking, J. Geophys. Res., *96*, 11609, 1991.

Jankowska, K., Elphinstone, R.D., Murphree, J.S., Cogger, L.L., Hearn, D. and Marklund, G., The Configuration of the Auroral Distribution for Interplanetary Magnetic Field Bz Northward, 2, Ionospheric Convection Consistent with Viking Observations, J. Geophys. Res., *95*, 5805, 1990.

Kelley, M. C., Swenson, C., Brenning, N., Baker, K., and Pfaff, R., Electric and Magnetic Field Measurements inside a High Velocity Beam Undergoing Ionization, J. Geophys. Res., Vol. 96, 9703, 1991.

Laurent, B. and Carlqvist, P., Relativistic Fireworks, Astrophys. Space Sci., *181*, 211, 1991.

Lindqvist, P.-A. and Marklund, G.T., A Statistical Study of High-Altitude Electric Fields Measured on the Viking Satellite, J. Geophys. Res., *95*, 5867, 1990.

Lindqvist, P.-A. and Mozer, F.S., The Average Tangential Electric Field at the Noon Magneto-pause, J. Geophys. Res., *95*, 17137, 1990.

Lundin, R., Gustafsson, G., Eriksson, A.I. and Marklund, G.T., On the Importance of High-Altitude Low-Frequency Electric Fluctuations for the Escape of Ionospheric Ions, J. Geophys. Res., *95*, 5905, 1990.

Marklund, G. T., Blomberg, L.G., Fälthammar, C.-G., Erlandson, R.E., and Potemra, T.A., Signatures of the High-Altitude Polar Cusp and Dayside Auroral Regions as Seen by theViking Electric Field Experiment, J. Geophys. Res., *95*, 5767, 1990.

Marklund, G., Vikingafärder avslöjar norrskenets hemlighet, pp. 14–16 in *Mellan Himmel och Jord*, Royal Inst. of Technology, Central Information, Stockholm, Sweden, 1991.

Marklund, G. T., and Blomberg, L. G., On the Influence of Localized Electric Fields and Field-Aligned Currents Associated With Polar Arcs on the Global Potential Distribution, J. Geophys. Res., *96*, 13977, 1991.

Marklund, G. T., and Blomberg, L.G., Toward a Better Understanding of the Global Auroral Electrodynamics Through Numerical Modeling Studies, pp 305–319 in Magnetospheric Substorms, Geophys. Monograph 64, Eds. Kan, J. R., Potemra, T. A., Kokubun, S. and Iijima, T., 1991.
Marklund, G. T., Blomberg, L. G., Murphree, J. S., Elphinstone, R. D., Zanetti, L. J., Erlandson, R.E., Sandahl, I., de la Beaujardière, O., Opgenoorth, H., and Rich, F.J., On the Electrodynamical State of the Auroral Ionosphere During Northward IMF: A Transpolar Arc Case Study, J. Geophys. Res., *96*, 9567, 1991.
Pottelette, R., Malingre, M., Dubouloz, N., Aparicio, B., Lundin, R., Holmgren, G. and Marklund, G., High-Frequency Waves in the Cusp/Cleft Regions, J. Geophys. Res., *95*, 5957, 1990.
Rothwell, P. L., Silevitch, M., Block, L. P., and Fälthammar, C.-G., Pre-Breakup Arcs – A Comparison between Theory and Experiment, J. Geophys. Res., 13967, 1991.
Sandahl, I., Eliasson, L., Pellinen-Wannberg, A., Rostoker, G., Block, L.P., Erlandson, R.E., Friis-Christensen, E., Jacobsen, B., Lühr, H. and Murphree, J.S., Distribution of Auroral Precipitation at Midnight During a Magnetic Storm, J. Geophys. Res., *95*, 6051, 1990.
Sandahl, I. and Lindqvist, P.-A., Electron Populations Above the Nightside Auroral Oval During Magnetic Quiet Times, Planet. Space Sci., *38*, 1031, 1990.
Sauer, H., Baumgärtel, K., Axnäs, I. and Brenning, N., A Fluid Simulation of the AMPTE Solar Wind Lithium Release, Adv. Space Res., *10*, No. 7, 95, 1990.
Schmieder, B., Dere, K.P., Raadu, M.A., Démoulin, P. and Alissandrakis, C.E., Relationship between a Spot and a Filament observed during Spacelab 2 Mission, Adv. Space Res., *10*, 195, 1990.
Stenbaek-Nielsen, H.C., Wescott, E.M., Rees, D., Valenzuela, A. and Brenning, N., Non-Solar UV Ions Observed Optically from the "CRIT I" Critical Velocity Ionization Experiment, J. Geophys. Res., *95*, 7749, 1990.
Turitsyn, S.K., Rasmussen, J.J. and Raadu, M.A., Stability of shocklike solutions in weakly dispersive media. In "Nonlinear World" Proc. IV International Workshop on Nonlinear and Turbulence Processes in Physics, Kiev, U.S.S.R., 9 – 22 October, 1989 (Ed. Sitenko, A.G., Zakharov, V.E,. and Chernousenko, V.M.,), *1*, 187, 1990.
Zanetti, L.J., Potemra, T.A., Erlandson, R.E., Bythrow, P.F., Anderson, B.J., Murphree, J.S. and Marklund, G.T., Polar Region Birkeland Current, Convection, and Aurora for Northward Interplanetary Magnetic Field, J. Geophys. Res., *95*, 5825, 1990.

Section for Atmospheric Physics, Department of Meteorology, Stockholm University

Murtagh, D P, G Witt, J Stegman, I C McDade, E J Llewellyn, F Harris and R G H Greer, An Assessment of Proposed $O(^1S)$ and $O_2(b^1\Sigma_g{}^+)$ Nightglow Excitation parameters., Planet. Space Sci., 38, 1, 43–53, 1990
Zuber, A., Resonance Light Sources and their Use in Atmospheric Research, Ph D Thesis, Department of Meteorology, University of Stockholm, 1989.
Friedrich, M., K.M. Torkar, D. Krankowsky, P. Lämmerzahl, G. Witt and A. Zuber, Case Study of Modelled and Measured D-Region Plasma Densities.J.Atmos Terr. Phys. 52, 10/11, 1085–1093, 1990.
Stegman, J., D Murtagh and G Witt, O_2 Herzberg II Bands in the Terrestrial

Nightglow, AGU Fall Meeting, San Francisco, EOS Trans. (Paper SA01–01), 1990.
Stegman, J., Spectroscopic and Kinetic Studies of Atmsopheric Oxygen Emission, Ph D Thesis, Stockholm University, 1991
Stegman, J., Spectral Composition of the Terrestrial O_2 UV Nightglow, Encyclopedia of Earth Systems Science, Vol 4, p.289–295, Academic Press.
Stegman, J. and D.P. Murtagh, The Molecular Oxygen Band Systems in the UV Nightglow; Measured and Modelled. Planet Space Sci, 39, 4, 595–609, 1991.
Espy, P.J. and G Witt, Climatology of High-Latitude, Mesospheric Hydroxyl During the Summer Noctilucent Cloud Season, AGU Fall Meeting, San Francisco, EOS Trans. (Paper SA51A-01), 1991.
Stegman, J., Extremes of Oxygen Airglow Intensity, AGU Spring Meeting 1992, Montreal, EOS Trans. (SA22C-11), 1992.
Wälchli, U., D P Murtagh and G Witt, On the Measurement of Oxygen Atom Concentration in the Lower Thermosphere, COSPAR Symposium 1992, Washington DC, (Paper C.2-S.01), 1992
Wälchli, U., J Stegman, G Witt, P. Espy, J. Y. N. Cho, C Miller, M.C. Kelley and W I Swartz, NLC and PMSE Observations by the CUPRI radar and by optical and electrical instruments on the night of 9/10 August 1991 durnig the NLC-91 campaign, COSPAR Symposium 1992, Washington D C, (Paper C.2-S49), 1992.

Lund Observatory, University of Lund

Ardeberg, A. and Lindgren, H.: Orbital Elements for Double Stars of Population II. The System HD 89499, Astron. Astrophys. 244, 310
DeLaPeña, M.D., R.A. Shaw, P. Linde and D. Dravins: An Accurate Registration Technique for Distorted Images, *in* Evolution in Astrophysics, IUE astronomy in the era of new space missions, ESA SP-310, 617, 1990
Dravins, D.: Stellar activity cycles, in Evolution in Astrophysics, IUE astronomy in the era of new space missions, ESA SP-310, 61, 1990
Dravins, D., L. Lindegren, Å. Nordlund and D.A. VandenBerg: The Distant Future of Solar Activity – A Case Study of Beta Hydri. I. Stellar evolution, lithium abundance, and photospheric structure, Astrophys. J., 1992, submitted
Dravins, D., P. Linde, K. Fredga and G. Gahm: The Distant Future of Solar Activity – A Case Study of Beta Hydri. II. Chromospheric activity and variability, Astrophys. J., 1992, submitted
Dravins, D., P. Linde, T.R. Ayres, J.L. Linsky, B. Monsignori-Fossi, T. Simon and F. Wallinder: The Distant Future of Solar Activity – A Case Study of Beta Hydri. III. Transition region, corona, and stellar wind, Astrophys. J., 1992, submitted
Grün, E., H. Fechtig, M.S. Hanner, J. Kissel, B.A. Lindblad, D. Linkert, G Morfill and H.A. Zook: In-Situ Exploration of Dust in the Solar System and Initial Results from the Galileo Dust Detector *in* Proc. IAU Coll. No 126, Kyoto, 1991.
Lindblad, B.A.: The Orbit of the Eta Aquarid Meteor Stream, *in* Asteroids, Comets, Meteors III, Uppsala 1990, pp. 551–553
Lindblad, B.A.: Coronal Sources of High Speed Plasma Streams in the Solar Wind During the Declining Phase of Solar Cycle 20, Astrophys. and Space Science, 1990, 170, pp. 55–61.

Lindblad, B.A.: A Study of Meteor Orbits Obtained in Japan, *in* Proc. IAU Coll. No. 126, Kyoto, 1991.
Lindblad, B.A.: The IAU Meteor Data Center in Lund, *in* Proc. IAU Coll. No. 126, Kyoto, 1991.
Lindblad, B.A.: A Computer search for Asteroid Families, *in* Asteroids, Comets, Meteors 91, Flagstaff 1992, in press
Lindblad, B.A., C.-I. Lagerkvist, H. Rickman and M. Lindgren: Asteroids, Comets, Meteors III, Proc. of a symposium held in Uppsala 1990
Lindblad, B.A. and D. Olsson-Steel: The Monocerotid Meteor Stream and Comet Mellish, 1990. Bull. Astron. Inst. Czechosl., 41, pp. 193–200
Lindblad, B.A. and V. Porubçan: The Orbit of the Lyrid Meteor Stream, 1991, Bull. Astron. Inst. Czechosl., 42, pp. 354–359.
Lindblad, B.A. and M. Simek: The Activity Curve of the Perseid Meteor Stream as Determined from Short-Duration Meteor Radar Echoes, *in* Asteroids, Comets, Meteors III, Uppsala, 1990, pp. 567–570
Linde, P.: Crowded Field Photometry with HST: A Simulation, *in* Proceedings of 3rd ESO/ST-ECF Data Analysis Workshop, ed. Grosbol, P.J. and Warmels, R.H., 1991
Linde, P. and D. Dravins: Enhancing IUE Spectrophotometry: A Case Study of Beta Hydri, *in* Evolution in Astrophysics, IUE astronomy in the era of new space missions, ESA SP-310, 605, 1990
Lindegren, L.: Hipparcos Reduction Overview, Advances in Space Research, Vol. 11, No. 2, (2) 25, 1991
Lundstedt, H.: An Inductive Expert System for Solar Terrestrial Predictions, *in* Proceedings of a Workshop at Leura, Australia, 1989, Vol. 2, NOAA.
Lundstedt, H.: Neural Network Predictions of Geomagnetic Activity, *in* IAGA programs and Abstract, XX General Assembly, IUGG, Vienna, 1991
Lundstedt, H.: Neural Networks and Predictions of Solar-Terrestrial Effects, Planetary Space Sciences, Vol. 40, pp. 457–464, 1992
Söderhjelm, S.: Double Star Observations with Hipparcos, *in* Nordic-Baltic Astronomy Meeting, editors Lagerkvist, Kiselman & Lindgren, 329, 1991

Stockholm Observatory, Stockholm University

Nordh, H.L., Olofsson, S.G. 1990: "A liquid helium cooled Fabry-Perot spectrometer for balloon-borne astronomical observations", Infrared Physics,*30*, 187.
Gahm, G.F., Gebeyehu, M., Lindgren, M., Magnusson, P., Modigh, P., Nordh, H.L. 1990: "The clearing of dust by a possible supernova remnant in Lupus", Astron. Astrophys. *228*, 477
Olofsson, S.G., Nordh, H.L. et al 1990: "The MOSES Astronomy Proposal". In Proceedings from the NSSR meeting in Bolkesjo, p. 105
Nordh, H.L., Olofsson, S.G. et al 1990: "MOSES – A proposed Swedish Submillimetre Satellite for Combined Astronomical and Atmospheric Observations". In Proc. from the 29th Liege Symposium, ESA SP-314, 387.
Gahm, G.F. 1990: "Flares on T Tauri stars", in IAU Symposium 137, p. 197
Gahm, G.F. 1990: "Star Formation after Core Collapse", in Proc. 24th ESLAB Symposium, p. 43.
Dravins, D., Linde, P., Fredga, K., Gahm, G.F. 1991: "The distant Future of Solar Activity – a Case Study of β Hydri II. Chromospheric Activity and Variations". submitted to Astrophys. J.

Planetary System Group, Astronomical Observatory, Uppsala University

Dahlgren, M., Fitzsimmons, A., Lagerkvist, C.-I., Willians, I.P.: (1991), "Differential CCD Photometry of Distant Asteroids". *Mon. Not. R. Astr. Soc.* 250, 115–118.

Eriksson, A., Cutispoto, G., Debehogne, H., Hahn, G., Lagerkvist, C.-I., Lindgren, M., Magnusson P. (1991), "Physical Studies of Asteroids XXIII. Photometric Observations of the Asteroids 6, 32, 196, 243, 416, 532 and 1580", *Astron. Astrophys. Suppl. Ser.*, 91, 259–269.

Festou, M., Rickman, H., Kamél, L. (1990), "Comet Light Curve Asymmetries and Nongravitational Effects: Statistical Correlation and Application to the Prediction of Comet Returns", Nature 345, 235.

Green, D.W.E., Rickman, H., Porter, A.C., Meech, K.J. (1990), "The Strange Periodic Comet Machholz", Science 247, 1063.

Hahn, G., Lagerkvist, C.-I., Lindgren, M., Dahlgren, M. (1991), "Orbital Evolution Studies of Asteroids Near the 5:2 Mean Motion Resonance with Jupiter", *Astron. Astrophys.*, 246, 603–618.

Lagerkvist, C.-I. (1991), "The Orbiting Planetary Telescope", in Proc from NSSR meeting, ed. B.N. Andersen, pp. 123–125.

Lagerkvist, C.-I., Barucci, M.A., Capria, M.T., Dahlgren, M., Fulchignoni, M., Magnusson P.: (1992), " Asteroid Photometric Catalogue, Second Update," Uppsala Astron. Obs., Uppsala.

Lagerkvist, C.-I., Magnusson, P. (1990), Analysis of Asteroid Lightcurves II. Absolute Magnitudes and Slope Parameters in a Generalized HG-System, *Astron. Astrophys. Suppl. Ser.* 86, 119–165.

Magnusson P., Barucci, M.A., Binzel, R.P., Blanco, C., Di Martino, M., Goldader, J.D., Gonano-Beurer, M., Harris, A.W., Michalowski, T., Mottola, S., Tholen, D.J., Wisniewski, W.: (1992), "Asteroid 951 Gaspra: Pre-Galileo Physical Model", Icarus, in press.

Magnusson, P., Lagerkvist, C.-I. (1990), Analysis of Asteroid Lightcurves I. Data Base and basic Reduction *Astron. Astrophys.* 86, 45–51.

Rickman, H.: "The Thermal History and Structure of Cometary Nuclei", in *Comets in the Post-Halley Era,* eds. R.L. Newburn Jr., M. Neugebauer, J. Rahe, Vol. 2, pp. 733–769, 1991.

Rickman, H.: "On the Properties of Comets, Asteroids, and Terrestrial Planet Impactors", *Adv. Space Res.* 11 (6), 7–18, 1991.

Rickman, H.: "Cometary Nuclei – Recent Gas Flux Modelling and Applications", *Ann. Geophys.* 10, 157–168, 1992

Rickman, H., Fernândes, J.A. Gustafson, B.Å.S. (1990), "Formation of Stable Dust Mantles on Short-Period Comet Nuclei", Astron. Astrophys. 237, 524.

Rickman, H., Festou, M.C., Tancredi, G., Kamél, L.: "Twentieth Century Light Curves and the Nucleus of Comet P/Tempel 2", procs. of *Asteroids, Comets, Meteors 1991,* 4 pages, in press.

Rickman, H., Froeschlé, C., Kamél, L, Festou, M.: "Nongravitational Effects and the Aging of Periodic Comets", *Astron. J.* 102, 1446–1463, 1991.

Onsala Space Observatory, Department of Radio and Space Science, plus the Millimetre wave group, Chalmers University of Technology, Gothenburg

Aalto, S., Booth, R.S., Johansson, L.E.B., Bergvall, N., 1990. *Molecular Clouds in NGC 3256,* in "Dynamics of Galaxies and Molecular Cloud Distribution", IAU Symposium No. 146, eds. F. Combes and F. Casoli, Kluwer Academic Publishers.

Aalto, S., Johansson, L.E.B., Booth, R.S., 1990. *The* $^{12}CO/^{13}CO$ Intensity Ratio in External Galaxies, in "Dynamics of Galaxies and Molecular Cloud Distribution", IAU Symposium No. 146, eds. F. Combes and F. Casoli, Kluwer Academic Publishers.

Acharya, P.R., Johansson, J.F., Kollberg, E.L., 1990. *Slotline Antennas for Millimeter and Submillimeter Waves,* in "Proceedings of the 20th European Microwave Conference", pp. 353–358.

Albinsson, B., 1992. *Development of Limbsounder Critical Receiver Technologies, Final Report Preamplifier with Cooled HEMT:s,* Prep. for ESA under ESTEC contract number AO/1–2292/89/NL/PB.

Askne, J., 1990. *General Principles of Relevant Satellite Systems,* in "Microwave Remote Sensing for Oceanographic and Marine Weather Models", Kluwer Academic Publishers.

Askne, J., 1990. *Potential hos Satellitburen Syntetisk Aperturradar för Iskartläggning,* in "RVK 90", ed. B.O. Rönnäng, Chalmers Tekniska Högskola, pp. 494–496.

Bergman, P., Hjalmarson, Å., 1989. *Methyl Cyanide (CH^3CN) in Molecular Cloud Cores,* in "The Physics and Chemistry of Interstellar Molecular Clouds", eds. G. Winnewisser and J.T. Armstrong, Springer-Verlag, pp. 124–126.

Black, J.H., van Dishoeck, E.F., 1990. *Electron densities and the excitation of CN in molecular clouds,* Astrophys. J., in press.

Booth, R.S., 1990. *New Millimetre Telescopes for VLBI,* in "Frontiers in VLBI", eds. H. Hirabayashi and M. Inoue, Universal Academy Press.

Booth, R.S., 1990. *Radio Astronomy today and the prospects for the future,* in "RVK 90", ed. B.O. Rönnäng, Chalmers Tekniska Högskola, pp. 17–29.

Booth, R.S., 1990. *The European VLBI Network, EVN,* in "Frontiers in VLBI", eds. H. Hirabayashi and M. Inoue, Universal Academy Press.

Booth, R.S., 1990. *The European VLBI Network,* in "Space VLBI", COSPAR symposium, The Hague.

Bååth, L.B., 1990. *Global Fringe Fitting Applied to 100 GHz VLBI Data,* in "Frontiers in VLBI", eds. H. Hirabayashi and M. Inoue, Universal Academy Press.

Bååth, L.B., 1990. *mmVLBI vs. VSOP,* in "Frontiers in VLBI", eds. H. Hirabayashi and M. Inoue, Universal Academy Press.

Bååth, L.B., 1990. *Results from 100 GHz VLBI,* in "Frontiers in VLBI", eds. H. Hirabayashi and M. Inoue, Universal Academy Press.

Bååth, L.B., 1990. *VLBI Observations at 100 GHz,* in "Parsec scale radio jets", eds. J.A. Zensus and T.J. Pearson, Cambridge University Press, pp. 91–97.

Bååth, L.B., 1991. *Global Fringe Fitting of Mk3 VLBI data,* IAU Coll. 131: Radio Interferometry, eds. Cornwell and Perley, Cam. Univ. Press, 321–325

Bååth, L.B.and Booth,R.S., 1991. *Mm VLBI – High resolution imaging,* IAU Coll. 131: Radio Interferometry, eds. Cornwell and Perley, Cam. Univ. Press, 326–329

Bååth, L.B., Padin, S., Woody, D., Rogers, A.E.E., Wright, M.C.H., Zensus, A., Kus, A.J., Backer, D.C., Booth, R.S., Carlström, J.E., Dickman, R.L., Emerson, D.T., Hirabayashi, H., Hodges, M.W., Inoue, M., Moran, J.M., Morimoto, M., Pavne, J., Plambeck, R.L., Predmore, C.R., Rönnäng, B.O., 1991. *The*

Microarcsecond Structure of 3C273 at 3 mm, Astron. Astrophys., 241, L1.

Carlström, A., 1990. *Discrimination of low-salinity sea ice types using VV- and VH-polarization C-band SAR imagery*, in "Proceedings of IGARSS'90", Washington, pp. 2233–2236.

Chen, C.-D., 1990. *Fabrication Procedures for Nb/Nb-oxide/Pb-alloy Edge-Type SIS Tunnel Junctions for Submillimetre-Wave Mixers*, Technical Report No. 88L, School of Electrical and Computer Engineering, Chalmers University of Technology.

Davis, J.L., and Elgered, G., 1990. *Using Radiometer Data to Study Atmospheric Water Vapor: ii. Modelling Inhomogeneties*, EOS, 70.

Dhawan, V., Bartel, N., Rogers, A.E.E., Krichbaum, T.P., Witzel, A., Graham, D.A., Pauliny-Toth, I.I.K., Rönnäng, B.O., Hirabayashi, H., Inoue, M., Lawrence, C.R., Shapiro, I.I, Burke, B.F., Booth, R.S., Readhead, A.C.S., Morimoto, M., Johnston, K.J., Spencer, J.H., Marcaide, J.M., 1990. *Further 7 millimetre VLBI observations of 3C84 and other sources with 100 microarcsecond angular resolution*, Astrophys. J. **360**, pp. L43-L46.

Elgered, G., Davis, J.L., 1990. *Spectral Analysis of Atmospheric Water Vapour Observed with Microwave Radiometry*, in "RVK 90", ed. B.O. Rönnäng, Chalmers Tekniska Högskola, pp. 489–493.

Elgered, G., Davis, J.L., Herring, T.A., Shapiro, I.I., 1991. *Geodesy by Radio Interferometry: Water Vapour Radiometry for Estimation of the Wet Delay*, J. Geophys. Res.,96, 6541–6555

Elgered, G., Johansson, J.M., Rönnäng, B.O., 1990. *Characterizing Atmospheric Water Vapour Fluctuations Using Microwave Radiometry*, Research Report No 165, Department of Radio and Space Science with Onsala Space Observatory, Chalmers University of Technology.

Emrich, A., 1990. *A Flexible Hybrid Spectrometer for Balloon Borne and Ground Based (Sub)millimeter Wavelength Astronomy*, Exp. Astron. 1, pp. 227–235.

Emrich, A., 1990. *The Millimeter Multibeam System Project at Onsala Space Observatory*, in "Submillimetre Astronomy", eds. G.D. Watt and A.S. Webster, Kluwer Academic Publishers, pp. 61–62.

L.D. Farmer, D.L. Bell, F. Fetterer, C.E. Livingstone, T.I. Lukowski,S.A.Digby, L.M.H. Ulander, A. Carlström, M.R. Drinkwater, L.D. Arsenault and A. Kovacs, 1991. *Beaufort Sea Ice – 1, an Overview*, IGARSS'91/URSI meeting held in Espoo, Finland, 3–6 June 1991, ISBN 951–95377–8-3, pp. 139.

Gray, A.L., Vachon, P.W., Ulander, L.M.H., 1990. *Processor focus, multilooking, and scene coherence: Implications for calibration of SAR image data*, in "Proceedings of IGARSS'90", Washington, pp. 1113–1116.

Grönqvist, H., Kollberg, E., Rydberg, A., 1991. *Quantum well and quantum barrier diodes for generating sub-millimeter wave power*, Microwave and Optical Technology Letters, Vol. 4, pp. 33–38.

Hayling, K.L., Noréus, J.P., and Wannäs, K.O., 1991. *Resolution of Satellite Altimetry and Marine Gravity Offshore the US East Coast*, presented at 61st Meeting of the Society of Exploration Geophysicists, November, Houston, Texas.

Hjalmarson, Å., 1990. *Are interstellar molecules of astrophysical interest?*, in "Proceedings of the Nordic-Baltic Astronomy Meeting", eds. D. Kiselman and C.-I. Lagerkvist, Uppsala.

Irvine, W.M., Madden, S.C., Ziurys, L.M., Friberg, P., Hjalmarson, Å. Matthews, H.E., Turner, B.E., 1990. *Observations of the CH_2CN 10,1-00,0 and 40,4-30,3 Transitions*, in "Submillimetre Astronomy", eds. G.D. Watt and A.S. Webster, Kluwer Academic Publishers, pp. 115–116.

Israelsson, H. and Askne, J., 1991. *Analysis of Polarimetric SAR Observations of Sea*

Ice, Proceedings of IGARSS'91, Helsinki, pp.703–705.
Israelsson, H. and Askne, J., 1991. *Analysis of Forested Areas as Part of the MAESTRO-1 Program*, Proceedings of IGARSS'91, Helsinki, pp.703–705.
Israelsson, H. and Askne, J., 1991. *Analysis of Polarimetric SAR Observations of Sea Ice*, Proceedings of IGARSS1/291 held in Espoo, Finland, 3–6 June 1991, IEEE 91CH2971–0, pp. 89–92.
Israelsson, H. and Sylvander, R., 1991. *The Use of Polarimetric SAR Data for Estimation of Forest Characteristics*, Proceedings of Remote Sensing for Forest Applications, Copenhagen.
Jacobsson, S., Johansson, J., Lundgren, A., 1990. *Computer Generated Phase Holograms (Kinoforms) for Millimeter and Submillimeter Wavelengths*, Intl. J. Infrared and Millimeter Waves, **11**.
Johansson, J.F., Kollberg, E.L., 1990. *Quasi-Optical Techniques*, in "Coherent Detection Techniques at Millimeter Wavelengths and Their Applications", eds. E.L. Kollberg, S. Gulkis, G. Winnewisser, and P. Encrenaz, Nova Science Publishers, chapter 5.
Johansson, J.F., Murowinski, R.J., Whyborn, N.D., 1990. *The Quasioptics and Receiver for SISYFOS*, in "RVK 90", ed. B.O. Rönnäng, Chalmers Tekniska Högskola, pp. 583–586.
Johansson, J.F., Whyborn, N.D., Acharya, P.R., Ekström, H., Jacobsson, S,W., and Kollberg, E.L., *Antennas for Sub-Millimeter Wave Receivers*, Proc. 2nd Intl. Symp. on Space THz Technology, Feb. 26–28, 1991, JPL/CalTech, Pasadena, Cal., USA, pp. 63–81 (STU 9001556)
Johansson, J.M., Elgered, G., and Rönnäng, B.O., 1990. *Microwave Radiometry for corection of Radio Propagation Effects in the Wet atmosphere*, Proc. symp. on Radio Astronomical Seeing, eds. Baldwin and Wang, pp. 81–86, International Academic Publishers, Oxford.
Knee, L.B.G., Cameron, M., Liseau, R., 1990. *The low mass protostellar candidate NGC-1333/IRAS-1*, Astron. Astrophys. **231**, pp. 419–430.
Kollberg, E., Tolmunen, T., Frerking, M., and East, J.,1991. *Current Saturation in Submillimeter Wave Varactors*, Proc. 2nd Intl. Symp. on Space THz Technology, Feb. 26–28, 1991, JPL/CalTech, Pasadena, Cal., USA
Kollberg, E., 1992. *Terahertz SIS-Mixers for Space*, summary report from ESA project No. 7898/88/NL/PB.
Kollberg, E.L., Grönqvist, H., and Rydberg, A., 1991. *Quantum Well and Quantum Barrier Diodes for generating Submillimeter Wave Power*, Coherent Detection Techniques at Millimeter Wavelengths and Their Applications, P. Encrenaz, C. Laurent, S. Gulkis, E. Kollberg, and G. Winnewisser, Eds., pp. 49–72, ISBN 1–56072–012–3, Nova Science Publishers, New York
Krichbaum, T.P., Booth, R.S., Kus, A.J., Rönnäng, B.O., Witzel, A., Graham, D.A., Pauliny-Toth, I.I.K., Quirrenbach, A., Hummel, C.A., Alberdi, A., Zensus, J.A., Johnston, K.J., Spencer, J.H., Rogers, A.E.E., Lawrence, C.H., Readhead, A.C.S., Hirabayashi, H., Inoue, M., Morimoto, M., Dhawan, V., Bartel, N., Shapiro, I.I., Burke, B.F., Marcaide, J.M., 1990. *43 GHz-VLBI observations of 3C 273 after a flux density outburst in 1988*, Astron. Astrophys. **237**, pp. 3–11.
Laxon, S. and Askne, J., 1991. *Comparison of Geosat and SSM/I Mapping of Sea Ice in the Arctic*, Proceedings of IGARSS1/291 held in Espoo, Finland, 3–6 June 1991, IEEE 91CH2971–0, pp. 1593–1596.
Le Bertre, T., Nyman, L.-Å., 1990. *Observations of 86 GHz SiO maser emission in late-type stars*, Astron. Astrophys. **233**, pp. 477–485.
Leppäranta, M., Askne, J., and Thompson, T., 1991. *BEPERS to BEERS – from*

Preparations to Realization, Proceedings of IGARSS1/291 held in Espoo Finland, 3–6 June 1991, IEEE 91CH2971–0, pp. 1205–1209.

Leppäranta, M. and Sun Yan, 1991. *Use of Ice Velocities from SAR Imagery in Numerical Sea Ice Modeling*, Proceedings of IGARSS1/291 held in Espoo, Finland, 3–6 June 1991, IEEE 91CH2971–0, pp. 1233–1237.

Lindqvist, M., Nyman, L.-Å., Olofsson, H., Winnberg, A., 1991. *The Circumstellar Chemistry of Oxygen – Rich Stars*, in "Proceedings of the Nordic-Baltic Astronomy Meeting", eds. C-I. Lagerkvist, D. Kiselman, M. Lindgren, Uppsala, p.189.

Livingstone, C.E., Lukowski, T.I., Arsenault, L.D., and Ulander, L.M.H., 1991. *Beaufort Sea Ice -1: SAR ice interpretation*, World Meteorological Organization Operational Ice Remote Sensing Workshop held in September, Ottawa, Canada.

Loup, C., Forveille, T., Nyman, L.-Å., Omont, A., 1990. *CO observations of very cold southern circumstellar shells and pre-planetary nebulae*, Astron. Astrophys. **227**, pp. L29–32.

Lukowski, T.I., Hawkins, R.K., Daleman, P.S., Ulander, L.M.H., 1990. *CCRS Synthetic Aperture Radar Data Calibration – Status Report*, in "Proceedings of IGARSS'90", Washington.

Mirabel, I.F., Booth, R.S., Garay, G., Johansson, L.E.B., Sanders, D.B., 1990. *CO(1–0) emission from luminous infrared galaxies in the southern hemisphere*, Astron. Astrophys. **236**, pp. 327–332.

Noreus, J.P. *Effect of Water Vapour Corrections for Satellite Altimetry Measurements of the Geoid*, presented at International Union for Geodesy and Geophysics 20th General Assembly, Aug. 1991 (in press). Research Report No. 166, 1990

Olofsson, H., Carlström, U., Eriksson, K., Gustafsson, B., Willson, L.A., 1990. *Bright carbon stars with detached circumstellar envelopes – A natural consequence of helium shell flashes?*, Astron. Astrophys. **230**, pp. L13-L16.

Olofsson, H., Eriksson, K., Gustafsson, B., 1990. *A comparison of photospheric and circumstellar [HCN]/[CO] – ratios for bright carbon stars*, Astron. Astrophys. **230**, pp. 405–411.

Olofsson, H., Lindqvist, M., Nyman L.-Å., Winnberg, A., 1991. *Molecules in The Envelope of The Mira-variable TX Cam: The First Detection of CN in An Oxygen-rich Circumstellar Envelope*, Astr. Astroph., **245**, 611 .

Olofsson, H.:, 1991. *Mass Loss and Red Giant Evolution* (invited review), in "Proceedings of the Nordic-Baltic Astronomy Meeting", eds C.–I. Lagerkvist, D. Kiselman, M. Lindgren, Uppsala, p.223.

Skalare, A., 1990. *Planar Quasiparticle Mixer Structures for Millimetre and Sub-Millimetre Wave Receivers*, Technical Report No. 90L, School of Electrical and Computer Engineering, Chalmers University of Technology.

Sun Yan, Carlström, A., and Askne, J., 1991. *Classification of Baltic Sea Ice using Simulated ERS-1 SAR Imagery*, Proceedings of IGARSS1/291 held in Espoo, Finland, 3–6 June 1991, IEEE 91CH2971–0, pp. 1229–1232.

Tolmunen, T.J., Nilsen, S., Boric, O., Frerking, M.A., Kollberg, E., 1991. *Accurate Characterization of Varactors with 1 fF Capacitance*, 16th International Conference on Infrared and Millimeter Waves, Lausanne.

Ulander, L.M.H., 1991. *Accuracy of using points targets for SAR calibration*. IEEE Trans. Aerospace Electronic Systems, Vol. 27, No. 1, pp. 139–148.

Ulander, L.M.H., Hawkins, R.K., Livingstone, C.E., and Lukowski, T.I., 1991. *Absolute Radiometric Calibration of the CCRS SAR*, IEEE Trans. Geosci. Remote Sensing, Vol. 29, No. 6, pp. 922–933.

Ulander, L.M.H. and Carlström, A., 1991. *Radar Backscatter Signatures of Baltic Sea*

Ice, Proceedings of IGARSS1/291 held in Espoo, Finland, 3–6 June 1991, IEEE 91CH2971–0, pp. 1215–1218.
van der Veen, W., Olofsson, H., 1990. *Determinations of Mass Loss Rates*, in "From Miras to Planetary Nebulae: Which Path for Stellar Evolution?", eds. M.O. Mennessier and A. Omont, Editions Frontières, pp. 139–157.
Wannier, P.G., Andersson, B.-G., Olofsson, H., Ukita, N., Young, K., 1991. *Abundances in Red Giant Stars: Nitrogen Isotopes in Carbon-rich Molecular Envelopes*, Ap. J., **380**, 593.
Wendemo, B., 1990. *K-Band Low Noise Amplifiers*, Technical Report No. 83L, School of Electrical and Computer Engineering, Chalmers University of Technology.
Whyborn, N.D., Lindström, C.-O., 1990. *The 350 GHz SIS Receiver for SEST*, in "RVK 90", ed. B.O. Rönnäng, Chalmers Tekniska Högskola, p. 577.
Whyborn, N.D., Lindström, C.O., Shitov, S.V., Koshelets, V.P., Kovtonyuk, S.A., Ermakov, An.B., 1991. *Ultra Low Noise 100 GHz Receiver based on Parallel Biased SIS Arrays*, ISEC '91, Glasgow, (STU 622–90–01215)
Winnberg, A., Lindqvist, M., Olofsson, H., Henkel, C., 1991. *Detection of CO emission from Two Distant, Non-variable OH/IR-stars*, Astr. Astroph., **245**, 195.

Manne Siegbahn Institute, Stockholm

Kobayashi, M., P. Carlson and S. Berglund: Gamma-rays and $e^{\pm}$ streaming backward from a total-absorbing electromagnetic calorimeter, Nucl. Instr. Methods A302 (1991) 47.
Carlson, P., T. Francke, F. Pinz and M. Suffert: Proposal to use a NaF Ring Imaging Cherenkov Counter to measure the antiproton flux in the cosmic rays, MSI report 90-02 (1990).
Adams, J.H., P. Carlson et al.: Gamma ray astronomy with a magnetic rigidity spectrometer, XXI International Cosmic Ray Conference, vol. 4, p. 183 (1990).
Francke, T.: A ring Imaging Cherenkov Counter using a solid radiator, Thesis (1991).
Berezinsky, V., L. Bergström, P. Carlson and H. Rubinstein: Cosmology and the diffuse high energy gamma radiation, XXI International Cosmic Ray Conference, vol. 1, p. 177 (1990).
Berglund, S., P. Carlson, C. Geich-Gimbel and M. Kobayashi: A spaceborne CsI (Tl) Calorimeter for cosmic gamma rays, IEEE Trans. Nucl. Sci., 37 (1990) 2179.
Francke, T., M. Suffert and P. Carlson: Identification of antiprotons in space using a compact RICH counter, IEEE Trans. Nucl. Sci., to appear.

Division of Atomic Spectroscopy, Department of Physics, University of Lund.

Se. Johansson
"The iron group elements and the 'missing' opacity in ultraviolet and optical spectra of stars" in *"Atomic Spectra and Oscillator Strengths for Astrophysics and Fusion research"*, ed J E Hansen (North-Holland) 1990.
D.S. Leckrone, Se. Johansson, R.L. Kurucz and S.J. Adelman
"High resolution ultraviolet spectroscopy from space observatories – what Atomic Physics and Astrophysics can do for each other" in *"Atomic Spectra and*

Oscillator Strengths for Astrophysics and Fusion research", ed J E Hansen (North-Holland) 1990.

Se. Johansson and R.C.M. Learner
"The lowest $3d^64s4f$ subconfiguration of Fe I determined from laboratory and solar Fourier transform spectra in the infrared" Astrophys. J. 354, 755 (1990)

Se. Johansson
"Interpretation of infrared emission lines" in *"Cool stars, stellar systems and the sun"*, Proc. 6th Cambridge Workshop, Ed. G. Wallerstein. Astr.Soc.Pacific Conf.series, vol 9, p 307, (1990).

Se. Johansson
"Atomic spectra and oscillator strengths in astrophysics and fusion"
Comments. Atomic. Mol. Physics, vol XXIV, 159 (1990).

W. Feibelman, F. Bruhweiler and Se. Johansson
"Ultraviolet High Excitation Fe II Fluorescence Lines excited by O VI, C IV and H I resonance emission as seen in IUE spectra Astrophys J. 373, 649 (1991)

Se. Johansson
"High-Resolution Atomic Spectroscopy in the Infrared and its Applications to Astrophysics" in *"The infrared spectral region of stars"*, p. 87
eds. C Jaschek, Y Andrillat (Cambridge University Press), 1991.

Se. Johansson, M. Rosberg and F. Hamann
"Identification of new 14 eV Emission Lines of Fe II in the near-infrared spectrum of LkHα101" in *"The infrared spectral region of stars"*, p. 107 eds. C Jaschek, Y Andrillat (Cambridge University Press), 1991.

Se. Johansson, G. Nave, R.C.M. Learner and A.P. Thorne "New Identifications of highly-excieted Fe I lines around 4 μm in cool stars"in *"The infrared spectral region of stars"*, p. 189 eds. C Jaschek, Y Andrillat (Cambridge University Press), 1991.

D. S Leckrone, G. M. Wahlgren, Se. Johansson
"First results from the GHRS: High Resolution Observations of the 1942 Å Resonance Line of Hg II in the Chemically Peculiar B star chi Lupi". Ap J Letters, 377, L37 (1991)

A. Redfors
"Oscillator strengths for Y III and Zr III in the IUE region" Astron.Astrophys. 249, 589 (1991)

D.S. Leckrone, Se. Johansson, G.M. Wahlgren
"High Resolution UV Spectroscopy of the Chemically Peculiar B-Star Chi Lupi" in *"The first year of HST Observations"*, p.83, eds A.L. Kinney, J C Blades, (Space Telescope Science Institute, Baltimore), 1991.

Department of Casting of Metals, Royal Institute of Technology, Stockholm

H. Fredriksson: "Solidification mechanisms – A study of the crystallization process in metal alloys", Scandinavian Journal of Metallurgy 20 (1991) 43 - 49

H. Shahani. G. Amberg and H. Fredriksson: "On the formation of macrosegregations in unidirectionally solidified Sn-Pb and Pb-Sn alloys", to be published in Metallurgical Transactions.

A. Jarfors and H. Fredriksson: "On the Behaviour of TiC Particles in the Al-rich Corner of the Al-Ti-C Phase Diagram", Microgravity Science and Technology III/4, February 1991.

A. Jarfors, H. Fredriksson and L. Froyen: "On the thermodynamics and kinetics of carbides in the aluminium-rich corner of the Al-Ti-C phase diagram", Materials Science and Engineering, A135 (1991) 119–123.

B. Lei, L.B. Ekbom, A. Eliasson, A. Jarfors: Trita-Mac Rep. Materials Center, Royal Inst. Technology, Stockholm, (March 1990).
L.B. Ekbom, B.Lei, A. Eliasson, A. Jarfors: Adv. Space Res. 11, No 7, pp 331–335.
L.B. Ekbom: Scand. J. Metallurgy, 20 (1991), pp 190–197.
L.B. Ekbom, A. Eliasson: "Microgravity experiments during parabolic flights", ESA Workshop, ESA WPP-021, Oct 1991.

Crystal Growth Group, University of Sundsvall

M Levenstam, G Amberg, E Tillberg and T Carlberg: Weak flows in a floating zone configuration as a source of radial segregation. J. of Crystal Growth, 104, (1990), P. 641–652.
T Carlberg, S Wahlborn: Laser Heating Facility. WP 6000 of ESA study HTFT, Ref. No. AO/2-1189/87 (1990).
T Carlberg, M Levenstam: Laser-heating applied to microgravity experiments – A feasibility study. Microgravity Science and Tech., Vol. 4, No. 4 (1991), P. 254–261.

Environmental Physiology Laboratory, Karolinska Institutet, Stockholm

ANTONUTTO, G., D. LINNARSSON, P.E. DI PRAMPERO AND C.J. SUNDBERG. Cross-coupled stimulation of the inner ear and acute motion sickness susceptibility during cycloergometric exercise in the human centrifuge. 1991. (Report)
BERG, H.E., G.A. DUDLEY, T. HÄGGMARK, H. OHLSÉN AND P.A. TESCH. Effects of lowerlimb unloading on skeletal muscle mass and function in humans. J. Appl. Physiol. 70(4):1882–1885, 1991.
BERG, H.E., T. HÄGGMARK, H. OHLSÉN AND P.A. TESCH. Effekter av 4 veckors muskelavlastning med bibehållen ledrörlighet, med avseende på muskelns styrka och tvärsnitt. Abstract, Swedish Association of Sports Medicine Meeting, Stockholm, 17–20 May, 1990, p.16.
BERG, H.E., T. HÄGGMARK, H. OHLSÉN AND P.A. TESCH. Knästräckarfunktion och muskeltvärsnitt efter 4 veckors avlastning med bibehållen rörlighet i höft, knä och fotled. Läkaresällskapets handlingar, Hygiea, 99:1, 259, 1990.
BERG, H.E., B. TEDNER, AND P.A. TESCH. Acute fluid shifts influence lower limb muscle cross-sectional area. Abstract American College of Sports Medicine Annual Meeting, May 1991. Med. Sci. Sports Exercise 23:407, 1991.
BERG, H.E. AND P.A. TESCH. Oxygen uptake during concentric and eccentric resistive exercise using a new gravity-independent ergometer. Proceedings of the Fourth European Symposium on Life Sciences Research in Space, Trieste, Italy, May 28- June 1, 1990, (ESA SP-307, 1990), p.77.
BERG, H.E. AND P.A. Tesch. Force and power output during concentric and

eccentric resistive leg exercise using a gravity-independent non-electrical strength ergometer. Abstract, Aerospace Medical Association Scientific Meeting, USA, May 1991. Aviat. Space Environ. Med. 62:214, 1991.

BERG, H.E. AND P.A. TESCH. Muscular power and metabolic responses to resistive exercise using an ergometer designed for use in space. Abstract 9th IAA Man in Space Symposium, 17–21 June 1991. Köln, FRG.

CARDUS, D., D. LINNARSSON, W.G. McTAGGART AND B. TEDNER. Electric impedance measurements of body fluid shifts in simulated microgravity. Automedica 12:1875–1882, 1990.

COLLIANDER, E.B. AND P.A. TESCH. Effects of eccentric and concentric muscle actions in resistance training. Acta Physiol. Scand. 140:31–39, 1990.

COLLIANDER, E.B. AND P.A. TESCH. Responses to eccentric and concentric resistance training in females and males. Acta Physiol. Scand 141:149–156, 1990.

DUDLEY, G.A., P.A. TESCH, R.T. HARRIS, C.L. GOLDEN AND P. BUCHANAN. Influence of eccentric actions on the metabolic cost of resistance exercise. Aviat. Space Environ. Med. 62:678–82, 1991.

DUDLEY, G.A., P.A. TESCH, B.J. MILLER AND P. BUCHANAN. Importance of eccentric actions in performance adaptations to resistance training. Aviat. Space Environ. Med. 62:543–50, 1991.

EIKEN, O., C.J. SUNDBERG, M. ESBJÖRNSSON, A. NYGREN and L. KAIJSER. Effects of ischaemic training on force development and fibre-type composition in human skeletal muscle. Clin. Phys. 11:41–49, 1990.

HATHER, B.M., P.A. TESCH, P. BUCHANAN AND G.A. DUDLEY. Influence of eccentric actions on skeletal muscle adaptations to resistance training. Acta Physiol. Scand. 143:177–185, 1991.

HESSER, C.M., F. LIND AND D. LINNARSSON. Significance of airway resistance for the pattern of breathing and lung volumes in exercising humans. J. Appl. Physiol. 68:1875–1882, 1990.

KAIJSER, L., C.J. SUNDBERG, O. EIKEN, A. NYGREN, M. ESBJÖRNSSON, C. SYLVÉN AND E. JANSSON. Muscle oxidative capacity and work performance after training under local leg ischemia. J. Appl. Physiol. 69(2):785–787, 1990.

LINNARSSON, D. Columbus research instrumentation: On-site proportional mixing (OPM) of inhaled indicator gases for pulmonary experiments. Report to ESA 1990.

LINNARSSON, D. The body as a bioenergetic system – lessons from systems engineering and comparative physiology. Medicine and Science in Sports and Exercise 22:59, 1990.

LINNARSSON, D. Short instruction for astronaut training. Karolinska Institutet 1990.

LINNARSSON, D. Pulmonary perfusion and ventilation in microgravity rest and exercise. In: Sahm, P.R., M.H. Keller and B. Schiewe (Eds.). Research program of the German Spacelab mission D-2. Wissenschaftliche Projektfühung D-2, c/o DLR, Köln 1991. (p. 72–74)

LINNARSSON, D., R. ANSJÖN AND H. LARSSON. Cardiogenic oscillations of soluble and insoluble indicator gases in upright man in normal gravity 1991 (Preliminary report)

LINNARSSON, D., P.E. DI PRAMPERO, J. STEGEMANN, C.J. SUNDBERG, U. HOFFMANN and D. ESSFELD. Effects of short-lasting weightlessness on gas exchange during light exercise. ESA Fourth European Symposium on Life Sciences Research in Space, Trieste, Italy, 28 May – 1 June 1990 pp 9–11

LINNARSSON, D., B. TEDNER, Y. HARUNA AND P.E. DI PRAMPERO. Dynamics of ventilation and CO^2 exchange during exercise in transient weightlessness. March 20, 1991. (Preliminary report)

LINNARSSON, D., B. TEDNER, Y. HARUNA AND P.E. DI PRAMPERO. Gas exchange during exercise under short periods of microgravity. International Academy of Astronautics, 9th IAA Man in Space Symposium, Cologne, Germany, 17–21 June 1991. p. 28. (Abstract)

LINNARSSON, D., B. TEDNER and B. LINDBORG. Body fluid displacement, arterial blood pressure and heart rate during a simulated shuttle launch. Abstracts, Twelvth Annual Meeting of the IUPS Commission of Gravitational Physiology, Leningrad, 1990.

MATTSSON, E. Energy cost of level walking. Karolinska Institutet, Stockholm, 1990. Thesis.

MEKJAVIC, I.B., T. PASSIAS, C.J. SUNDBERG AND O. EIKEN. Behavioural temperature regulation during mild narcosis. Proceedings of the XVIIth Annual Meeting of the European Undersea Biomedical Society, Heraklion, Greece, 1991. p. 153–159, 1991.

MEKJAVIC, I.B. and C.J. SUNDBERG. The effect of mild narcosis on the sweating and shivering responses in humans. Undersea Biomed. Res. 17(Suppl.):174, 1990.

MEKJAVIC, I.B., C.J. SUNDBERG AND D. LINNARSSON. Core temperature "null zone". J. Appl. Physiol. 71(4):1289–1295, 1991.

ÖSTLUND, A., D. LINNARSSON, A. SPORRONG and F. LIND. Interaction of inert gas narcosis and moderately elevated hydrostatic pressure in man. Undersea Biomed. Res. 17(Suppl.): 49, 1990.

SUNDBERG, C.J., O. EIKEN, M. ESBJÖRNSSON, A. NYGREN, E. JANSSON AND L. KAIJSER. Effect of one-legged ischemic cycle training on dynamic muscle performance and glycogen storage. Medicine and Science in Sports and Exercise, 11(2) Suppl., 1990.

SUNDBERG, C.J., O. EIKEN, M. ESBJÖRNSSON, A. NYGREN AND L. KAIJSER. Effects on training with reduced perfusion pressure on performance and muscle fiber characteristics. ESA Fourth European Symposium on Life Sciences Research in Space, Trieste, Italy, 28 May – 1 June 1990. pp. 197–198.

SUNDBERG, C.J. AND L. KAIJSER. Leg blood flow during exercise with reduced perfusion pressure; Quantification of a human ischemia-model. Med. Sci. Sports Exerc. 23:4(Suppl.):S5, 1991.

SUNDBERG, C.J. AND L. KAIJSER. Effects of graded restriction of perfusion on circulation and metabolism in the working leg: Quantification of a human ischemia-model. Acta Physiol. Scand. 1991. (Submitted)

SUNDBERG, C.J., G. MAGNUSSON, H. GÖRANSSON AND L. KAIJSER. The influence of ischemic training on the force-velocity relationship and cross sectional area of human skeletal muscle. In: Proceedings of the 8th International Biochemistry of Exercise Conference, Nagoya, Japan, 1991. p. 78.

SUNDBERG, C.J., G. MAGNUSSON AND L. KAIJSER. Effects of reduced perfusion pressure on leg blood flow and muscle force responses to training. International Academy of Astronautics, 9th IAA Man in Space Symposium, Cologne, Germany, 1991. p. 48. (Abstract)

TESCH, P.A., H.E. BERG AND G.A. DUDLEY. Structure and function of different muscles and muscle groups following simulated microgravity. Abstract 9th IAA Man in Space Symposium, 17–21 June 1991. Köln, FRG.

TESCH, P.A., H.E. BERG, T. HÄGGMARK, H. OHLSÉN AND G.A. DUDLEY. Muscle function impairment following lower limb unloading in men. Proceed-

ings of the Fourth European Symposium on Life Sciences Research in Space Trieste, Italy, May 28- June 1, 1990, (ESA SP-307, 1990), pp.199–200.
TESCH, P.A., H.E. BERG, T. HÄGGMARK, H. OHLSÉN AND G.A. DUDLEY Muscle strength and endurance following lowerlimb suspension in man. The Physiologist 34: Suppl. S104–106, 1991.
TESCH, P.A., P. BUCHANAN AND G.A. DUDLEY. An approach to counteracting long-term microgravity-induced muscle atrophy. The Physiologist 33 Suppl. S77–79, 1990.
TESCH, P.A., A. THORSSON AND E.B. COLLIANDER. Effects of eccentric and concentric resistance training on skeletal muscle substrates, enzyme activities and capillary supply. Acta Physiol. Scand. 140:575–580, 1990.

Department of Physical Chemistry, Chalmers University of Technology, Gothenburg

Jonsson, M.; Jacobsson, U., Nordén, B., and Eriksson, T. (1992) Orientation of DNA during Free-solution Electrophoresis Studied under Microgravity Conditions in a Sounding Rocket Flight. ESA SP, in press.

Atomic Physics Division, Department of Physics, Lund Institute of Technology

Edner H., G.W. Faris, A. Sunesson, S. Svanberg, J.Ö. Bjarnarson, H. Kristmannsdpttir, and K.H. Sigurdsson, Lidar search for atmospheric atomic mercury in Iceland geothermal fields, J. Geoph. Res., 96, 2977–2985, 1991.
Edner H., P. Ragnarson, S. Svanberg, E. Wallinder, A. De Liso, R. Ferrara, and B.E. Maserti, Differential absorption lidar mapping of atmospheric atomic mercury in Italian geothermal fields, J. Geophys. Res., 97, 3779–3786, 1992.
Ferrara R., B.E. Maserti, H. Edner, P. Ragnarson, S. Svanberg, E. Wallinder, Mercury emissions into the atmosphere from a chlor-alkali complex measured with the lidar technique, Atm. Environ., in press.
Edner H., P. Ragnarson, S. Svanberg, E. Wallinder, R. Ferrara, B.E. Maserti and R. Bargagli, Atmospheric mercury mapping in a cinnabar mining area. STOTEN, in press.
Ferrara R., B.E. Maserti, H Edner, P Ragnarson, S. Svanberg and E. Wallinder. Atmospheric Mercury Determinations by Lidar and Point Monitors in Environmental Studies, to appear in Toxological Environmental Chemistry.
Edner H. and S. Svanberg, Lidar Measurements of Atmospheric Mercury. Water, Air and Soil Pollution 56: 131–139, 1991.
Edner H., P. Ragnarson, S. Svanberg, E. Wallinder, R. Ferrara, and B.E. Maserti. Differential absorption lidar mapping of atmospheric atomic mercury. Proc of the Tenth International Conference on Laser Spectroscopy, Font-Remy, Freance, June 17–21, 1991.
Edner H., P. Ragnarson, S. Svanberg, E. Wallinder, R. Ferrara, B.E. Maserti and R. Bargagli, Differential absorption lidar mapping of atmospheric atomic mercury of geophysical origin, CLEO 91.
Ferrara R., B.E. Maserti, M. Morelli, H. Edner, P. Ragnarson, S. Svanberg, E Wallinder, Vertical distribution of atmosphric mercury concentration over a

cinnabar deposit, Proc. Heavy Metals in the Environment, Edinburgh, Great Britain, Sept. 15–20, 1991.

Ferrara R., B.E. Maserti, A. De Liso, H. Edner, P. Ragnarson, S. Svanberg, E. Wallinder, Could the geothermal power plants at Mt. Amiata be a source of environmental mercury contamination?, Proc. of Effects of Atmospheric Pollutants on Climate and Vegetation, Taormina, Italy, Sept. 26–29, 1991.

Edner H.,P. Olsson, and P. Ragnarson, Undersökning av kvicksilveravgång från fibersediment med lidar-teknik, Lund Reports on Atomic Physics, LRAP-126, 1991.

Edner H., P. Ragnarson, S. Svanberg and E. Wallinder, Simultaneous Tropospheric Ozone Monitoring Using Lidar and Doas Systems, manuscript in preparation.

Edner H. and E. Wallinder, LTH Tropospheric Ozone Lidar Measurements During TROLIX '91, manuscript in preparation.

Edner H., P. Ragnarson, S. Svanberg and E. Wallinder, Vertical Lidar Probing of Ozone and Related Trace Species – A contribution to the EUROTRAC subproject TESLAS, to be published in the EUROTRAC Annual Report 1991.

Edner H., P. Ragnarson, S. Spännare, and S. Svanberg, A differential optical absorption spectroscopy (DOAS) system for urban atmospheric pollution monitoring, Applied Optics, in press.

Spännare S., An interactive steering system for differential optical absorption spectroscopy measurements, Lund Reports on Atomic Physics, LRAP-117.

Axelsson H., B. Galle, K. Gustavsson, P. Ragnarson and M. Rudin, A Transmitting/Receiving Telescope for DOAS Measurements using Retroreflector techniques, submitted to Applied Optics.

Axelsson H., H. Edner, A. Eilard, A. Emanuelsson B. Galle, H. Kloo, and P. Ragnarson, Measurements of aromatic hydrocarbons with the doas technique, submitted to Applied Spectroscopy.

Axelsson H., H. Edner, B. Galle, J. Mellqvist and P. Ragnarson, Development of DOAS for Atmospheric Trace Species Monitoring – A contribution to the EUROTRAC subproject TOPAS, to be published in the EUROTRAC Annual Report 1991.

Edner E., J. Johansson, S. Svanberg and E. Wallinder, LaserInduced Fluorescence Monitoring of Vegetation in Tuscany, EARSEL, Lidar Remote Sensing of Land and Sea, Firenze, Italy, May 6–8, 1991.

Edner H., J. Johansson, S. Svanberg and E. Wallinder, Fluorescence Lidar Monitoring of the Arno River, EARSEL, Lidar Remote Sensing of Land and Sea, Firenze, Italy, May 6–8, 1991.

Edner H., J. Johansson, S. Svanberg and E. Wallinder, Remote Multi-Color Imaging of Vegetation Laser-Induced Fluorescence, to be presented at CLEO 92.

Karlsson T., Studies on Vegetation using Laser Induced Fluorescence, Diploma Paper, Lund Institute of Technology, to appear.

Svanberg S., Environmental Monitoring using Optical Techniques, Applied Laser Spectroscopy, Edited by W.

Demtröder and M. Inguscio, Plenum Press, New York, 1990.

Svanberg S., Atmospheric Pollution Monitoring using Laser Lidars, Optoelectronics for Environmental Science, Edited by S. Martellucci and A.N. Chester, Plenum Press, New York, 1990.

Svanberg S., Laser Fluorescence Spectroscopy in Environmental Monitoring, Optoelectronics for Environmental Science, Edited by S. Martellucci and A.N. Chester, Plenum Press, New York, 1990.

Svanberg S., Laser Spectroscopy Applied to Energy, Environmental and Medical Research, invited paper at the fifth International Symposium on Resonance Ionization Spectroscopy and its Applications (RIS-90), Varese, Italy, 16–21 September, 1990.
Edner H., P. Ragnarson, S. Svanberg and E. Wallinder, Differential Absorption Lidar Monitoring of Atmospheric Atomic Mercury, to be presented at the International Symposium on Environmental Sensing, Berlin, 22–26 June 1992.
Edner H., P. Ragnarson, S. Svanberg and E. Wallinder, Remote Sensing of Pollutant Fluxes Using Differential Absorption Lidar, Conference on Optical Remote Sensing and Applications to Environmental and Industrial Safety Problems, Houston, Texas, April 6–9, 1992.

Department of Biometry and Forest Management, Remote Sensing Laboratory, Swedish University of Agricultural Sciences, Umeå

Eliasson A. 1991. Integration of Satellite Remote Sensing in a Forestry Oriented GIS. Scandinavian Journal of Forest Research vol 6, no 3 (pp 413–423).
Feychting H., Hagner O. and Nilsson M. 1991. Estimation of forest characteristics using neural networks and satellite remote sensing. In "Current Advances in the Use of Computers in Forest Research" Proceedings Workshop of the IUFRO Working Party S4, 11–03, Joensuu, Finland. Febr 14, 1991. Ed. Hannu Sarenmaa (pp 13–|7).
Hagner O. 1990a. Use of digital satellite data for stand delineation and estimation of stand variables by regression analysis and field inventory. Paper presented at ISPRS Commission VII, Midterm symposium, Sept 17–21, Victoria B C, Canada.
Hagner O. 1990b. Computer aided forest stand delineation and inventory based on satellite remote sensing. The usability of remote sensing for forest inventory and planning. Proceedings from SNS/IUFRO workshop in Umeå 26–28 Febr 1990. Remote Sensing Laboratory, Swedish University of Agricultural Sciences. Report 4 (pp 94–105).
Hagner O. 1991. A prototype GIS/Remote Sensing Work Station for forest map revision and updating. Paper presented at the SNS/JRC seminar on Remote Sensing for Forestry Applications. Copenhagen 13–15 Nov 1991 (8 pp).
Holmgren P. 1990. Digital Site Classification. Paper presented at ISPRS Commission VII Sept 17–21 in Victoria, B C Canada (10 pp).
Israelson H. and Sylvander R. 1991. The Use of Polarimetric SAR data for Estimation of Forest Charcteristics. Paper presented at SNS/JRC seminar on Remote Sensing for Forestry Applications. Copenhagen 13–15 Nov 1991 (in print) (9 pp).
Olsson H. 1990a. Standwise change detection by satellite data in a GIS environment – A test on snowbreak damaged Scots pine. In Proceedings from the SNS/IUFRO Remote Sensing and Forest Inventory Workshop. Swedish University of Agricultural sciences, Remote Sensing Lab. Report No 4 (pp 17–26).
Olsson H. 1990b. Spectral response from thinning cuttings measured by multitemporal satellite data. International Archives of photogrammetry and remote sensing. Volume 28 part 7–1 (pp 850–856).
Olsson H. 1991a. Combination of field data and remote sensing data. Seminars

of the United Nations Program on Space Application. Selected Papers on Remote Sensing and Satellite Communications 1991. United Nations Outer Space Affairs Division, New York.
Olsson H. 1991b. Comparison of regression functions for multitemporal image normalization of Landsat TM data over forest. Remote Sensing Laboratory, Swedish University of Agricultural Sciences, Report No 6.
Olsson H. 1991c. Standwise change detection- experiences from studies in northern Sweden. In Proceedings from SNS/JRC seminar on Remote Sensing for Forest Inventory. (In print) Copenhagen 13–15 Nov 1991.
Olsson H., Näsholm B., Hagner O. and Sylvander R. 1991. Early experience on the use of satellite borne S-band SAR over Swedish Forest. In Proceedings from SNS/JRC seminar on Remote Sensing for Forest Inventory (in print). Copenhagen 13–15 Nov 1991.
Sylvander R. and Poso S. 1990. The Usability of Remote Sensing for Forest Inventory and Planning. Proceedings from SNS/IUFRO workshop in Umeå 26–28 February 1990. Remote Sensing Sensing Laboratory, Swedish University of Agricultural Sciences, Umeå. Report No 4.
Sylvander R. 1991a. Kinematic GPS measurements with special emphasis on forestry applications in Swedish forestry. Paper presented at IGARSS' 91, 3–6 June in Helsinki, Finland (pp 1623–1626).
Sylvander R. 1991b. Kinematic GPS for aerial determination of position. Paper presented at SNS/JRC seminar in Copenhagen 13–15 Nov 1991 (9 pp) (in print).

Centre for Image Analysis in Uppsala, Uppsala

Classification of different land surfaces of the Quattara depression. Egypt, for the estimation of evaporation. 23rd Int Symp on Remote Sens. of Environment, Bangkok, 1990. Together with A. A. ElBassyony.
Optiske Målningar. In Eutrofisitutionen i Ytrre Oslofjord. (Optical measurements). With Kai Sörensen and E. Aas. NIVA Rapport 405/90.
Verifikation av modellresultater mot satellitdata. (Verfications of mathematical modelling of currents vs. satellite data). In Eutrofisitutionen i Ytrre Oslofjord. With Kai Sörensen L.P. Röed, J. Magnusson and T.B. Irman-Jacobsen. NIVA Rapport 414/90. Oslo 1990.
Optiske observatsjoner – overflatevannets kvalitet set ur observasjoener i overflatelagret og fjernmålning. (Optical observations – surface water quality from in-situ observations and remote sensing). In Eutrofisitutionen i Ytrre Oslofjord. With Kai Sörensen and K. Baalsrud. NIVA Rapport 387/90. Oslo 1990.
Erfaringer med bruk av satellitfjernmåling. (Experiences from the use of satellite data in limnology). Limnos, 1:1991. Together with K. Sörensen.
Satellite Mapping of oolitic ridges in Arabs Gulf, Egypt. Geocarto International. No 2:1991. Together with T. Alexandersson and John O. Norrman.
Nisell, J. and Wallsten, M.: The Catchment area of River Fyrisån Classified from Satellite Data and Digital Map Data. Vatten 47:291–298. Lund 1991.
Nisell, J.: Karaktäreisering av dräneringsområden för 26 referenssjöar (Characterization of drainage areas for 26 reference lakes). Environmental Protection Agency. Report 3766, 1991.
Lindell, T., Sörensen, K., Larsen, G. and Nisell, J.: Remote Sensing and the

Vertical Distribution of the Chrysochromulina polylepis Bloom in Skagerrak in 1988. Uppsala 1991.
Andersson, I: Gervais, P. and Jaakkola, S.: SPOT kontra Landsat TM för kartering av jordbruksgrödor. (SPOT versus Landsat TM for mapping of crops.

Department of Geology, Chalmers University of Technology, Gothenburg

Ericsson L O, Ronge B, 1986, Correlation between Tectonic Lineaments and Permeability Values of Crystalline Bedrock in the Gideå area. Technical Report 86-19 from Nuclear Fuel and Waste Management Co. Stockholm.
Ericsson L O, Ronge B, 1987, Interpretation of Lineaments with Landsat TM data in the Gothenburg area, Sweden, Hydrogeological Modelling ESA project, Geologiska Inst. CTH/GU, Göteborg.
Gråsjö M, Vestergren M, 1988, Lineamenttolkning i kristallin berggrund, hydrogeologisk modellering med satellitdata, Geologiska institutionen, Chalmers Tekniska Högskola och Göteborgs Universitet, Göteborg, publ. B 324, Göteborg.
Gråsjö M, 1990, Sprödtektonisk lineamenttolkning med hjälp av digital bildhantering och analys, Geologiska institutionen, Chalmers Tekniska Högskola och Göteborgs Universitet, Göteborg, publ. B 343, Göteborg.
Gråsjö et al, 1990, Satellites as Tools in Civil Engineering Projects, Swedish Space Corporation, Solna, publ. FUX 820-02.
Gråsjö M, Gustafsson P, Öberg M, 191, Interpretation of Tectonic Structures on Enhanced Satellite Images for Groundwater Exploration, Swedish Space Corporation, Solna, publ. FUX 830.

Remote Sensing Laboratory, Department of Physical Geography, Stockholm University

Alm, G., 1991: Ice detection during cloudy conditions over the Artic region using NOAA AVHRR satellite imagery. Geogr. Ann. 73 A (3–4):155–166.
Bax, G., Lundén, B. and Wester, K., 1990: Landsat satellite images for mapping of lineaments in the northern Scandinavian Caledonides and their Fennoscandian forelands.- Nord. Geol. Meeting, Stavanger 1990. 17(1):25.
Bax, G., Lundén, B., Wester, K., and Romer, R., 1991: Remote sensing techniques as mineral exploration tools in the Scandinavian Caledonides and their Fennoscandian forelands. – Proceedings of IGARSS'91 Symposium, Espoo, Finland, June 1991.
Lundén, B., and Nordberg, M-L., 1990: The first night-time Landsat satellite thermal infrared imagery over Sweden. A tool for climatological studies. – Geogr. Ann. 72A (1):1–12.
Lundén, B., and Nordberg, M-L., 1991: Night time Landsat thermal infrared imagery as a tool for climatological studies.- 5th International Colloquium on Physical Measurements and Spectral Signatures in Remote Sensing, Courchevel, France.
Lundén, B., Strömquist, L., and Nordström, A., 1990: An evaluation of soil erosion intensity mapping from SPOT satellite imagery by studies of colour aerial photographs and top-soil content of ^{137}Cesium. – Res. Report 74,

Department of Physical Geography, Uppsala University. pp 13–37.
Lundén, B., Wester, K., Bax, G., 1990: Satellite images for geological applications.- Swedish Space Cooperation. – FUX 810–01, 43 pp.
Lundén, B., Wester, K., and Bax, G., 1991: Satellite image enhancement for rock type separation.- Proceedings of IGARSS'91 Symposium, Espoo, Finland, June 1991.
Lundén, B., Wester, K., and Bax, G., 1991: Landsat TM for geological mapping in Saudi Arabia. – Swedish Space Corporation. FUX 810–02, 31 pp.
Syrén, P., 1991: Forest reflectance as a function of solar elevation and forest parameters. – Proceedings of IGARSS'91 Symposium, Espoo, Finland, June 1991.
Wester, K., 1991: User defined classification methods for lithological mapping using Landsat TM data. – Proceedings of IGARSS'91 Symposium, Espoo, Finland, June 1991.
Wester, K., Lundén, B., and Bax, G., 1990: Analytically processed Landsat TM images for visual geologic interpretation in the northern Scandinavian Caledonides. – Journal of Photogrammetry and Remote Sensing 45: 442–460.

The Lund Research Group in Applied Monitoring and Environmental Analysis, Remote Sensing and GIS Laboratory, University of Lund

Ardö, J., 1991: Samband mellan Landsat TM-data och skoglig produktivitet i södra Sverige. Svensk Geografisk ®rsbok.
Hall-Könyves, K., 1991: Agricultural Crop Area Estimation in Sweden. Presented at the 24th International Symposium on Remote Sensing of Environment, Rio de Janeiro, Brazil, 27–31 May.
Hall-Könyves, K., 1991: Application of AVHRR-LAC Data in Swedish Agriculture. Presented at the 24th International Symposium on Remote Sensing of Environment, Rio de Janeiro, Brazil, 27–31 May.
Hall-Könyves, K., 1990: Crop Monitoring in Sweden. Int. J. Remote Sensing, vol. 11, no. 3, 461–484.
Helldén, U., 1991: Desertification-Time for An Assessment? Ambio Vol. 20 No. 8, 372–383.
Larsson, H., 1991: Remote Sensing for Forest Canopy Cover Estimations in Semi-arid Environments. Proc. "Second International Symposium on Remote Sensing & Space 92, 16–18 January, 1992". 11 p.
Larsson, H. and Pilesjö, P., 1990: Remote Sensing for Forest Management in Semi-arid Environments. 23rd International Symposium on Remote Sensing of Environment, April 18–25, Bangkok, Thailand.
Pilesjö, P., 1990: GADD-Generation and Morphological Analysis of Digital Depth Information. User's Handbook. In Swedish. University of Lund. 18 p.
Pilesjö, P., Persson, J., and Håkansson, L., 1991: Digital bathymetric information for determination of morphometric parameters and surface water retention time for coastal areas. SNV Rapport 3916. In Swedish.
Pilesjö, P., 1991: Field Cover Estimation using Landsat MSS, Landsat TM and SPOT Data – A Comparison in Semi-arid Environments. 24th International Symposium on Remote Sensing of Environment, May 27–31, Rio de Janeiro, Brazil, 14 p.
Pilesjö, P., 1991: Automated Drainage Basin Detection and Theoretical Run-off Estimation from a Gridded Digital Elevation Model. Second European Conference on Geographical Information Systems, April 2–5, Brussels. 10 p.

Olsson, L., 1991: Desertification and Land Degradation in Perspective. Invited paper at the Sahel Conference in Dryland Degradation-causes and consequences. (Edited by Poulsen & Lawesson). Aarhus University Press.
Oxenstierna, A., 1991: Harvest Forcasting in the Sudan. 5th AVHRR Data User's Meeting, Tromsö, Norway.
Oxenstierna, A., 1991: Integration of Scanned Infrared Air Photos and Coordinate Files in ARC/INFO – a Biohabitat Example from Southern Sweden. EARSeL Workshop on Relationship of Remote Sensing an Geographic Information Systems. Hannover.

Environmental and Natural Resources Information Systems, Royal Institute of Technology, Stockholm

Johnsson, Katarina: Rule based extraction of spectrally heterogeneous land use categories from SPOT multispectral data.- Licentiate Thesis, 79 p, Department of Photogrammetry, The Royal Institute of Technology, Stockholm 1991
Larsson, Per: Experiments with Automatic Mapping of Lineaments in Crystalline Rocks with Remote Sensing and Digital Elevation Data. – Licentiate Thesis, 63 p, Department of Land and Water Resources and Department of Photogrammetry, The Royal Institute of Technology, Stockholm 1991
Svenson, Per & Huang, Zhexue: Geo-SAL: A Query Language for Spatial Data Analysis.- in Gunther,U & Schik,J (eds): Advances in Spatial Databases. Lecture Notes in Computer Science, vol. 525, Springer 1991

Swedish Environmental Research Institute, Stockholm

Ekstrand, S., 1990: Detection of Moderate Damage on Norway Spruce using Landsat TM and Digital Stand Data. IEEE Transactions on Geoscience and Remote Sensing, Vol. 28, No 4, July 1990, pp 685-692.
Ekstrand, S., 1991: Quantification of Chlorophyll *a* in Coastal Waters Using Landsat TM. Proc. of the 24th Int. Symp. on Remote Sensing of the Environment, Rio de Janeiro, Brazil, 27-31 May, 1991.
Ekstrand, S., 1992: Landsat TM Based Quantification of Chlorophyll *a* During Algae Blooms. Int. J. of Remote Sensing, in press
Ekstrand, S., 1992: Forest Decline Monitoring Using Landsat TM, Digital Stand Data and DEMs. Proc. of the European International Space Year Conference (central symp., session 4), Munich, Germany, 30 March – 4 April, 1992, in press.

Remote Sensing Applications Oceanography/Hydrology, Swedish Meteorological and Hydrological Institute, Norrköping

Thompson,T., Ulander.,L, Håkansson,B., Brusmark,B.,Carlström,A., Gustavsson, A., Cronström,E. and O. Faest (1991): BEERS-92 Baltic experiment for ERS-1, experiment plan. SMHI Oceanografi, No. 50, pp 50.
Håkansson, B. (1990): Remote sensing of the diffuse attenuation coefficient and chlorophyll concentration in a Baltic Sea bay. *Submitted.*
Leppäranta M. och Thompson T. (1989): BEPERS-88 Sea ice remote sensing with

synthetic aperture radar in the Baltic Sea. *Eos, Transactions, American Geophysics, July 11, 1989.*
Askne,J., Leppäranta,M. and T. Thompson (1991) The Bothnian Experiment in Preparation for ERS-1, 1988 (BEPERS-88) – an overview. To appear in Int. J. Remote Sensing.
Fransson L., Håkansson B., Omstedt A.and L. Stehn (1990): Sea ice properties studied from the icebreaker Tor during BEPERS-88. Winter navigation research board, Research report No. 48, pp 84.

National Defence Research Establishment (FOA), Department of Information Technology, Linköping

Bengtsson, M.: Perihelion Rotation in Kepler Motion – effects from a velocity dependent potential. FOA report C 30586–9.4, March 1990.
Ekblad, U.: Velocity Dependent Potentials and General Relativity. FOA report C 30562–9.4, January 1990.
Ekblad, U.: Military and Security Political Applications of Space Technology – Version 2 (in Swedish). FOA report C 30587–9.4, November 1990.
Ekblad, U.: Space Weapons Monitoring. FOA report C 30258–9.4, October 1991.
Ekblad, U.: Fourth International Castiglioncello Conference (in Swedish). FOA report D 30643–9.4, November 1991.
Ekblad, U., H-Å Olsson: Satellite Imagery Detection of Preparations for Underground Nuclear Explosions. FOA report C 30560–9.4, January 1990.
Gustavsson, A., B. Brusmark, A. Nelander, H. Ottersten: SAR Activities at FOA. Radarcon 90, Adelaide, 1990.
Hellsten, H., A. Gustavsson: CARABAS – Low Frequency SAR with Large Relative Bandwidth. Radarcon 90, Adelaide, 1990.
Lewerentz, B., H. Ottersten: COMSENS – a new satellite system with many applications: Both disarmament and environmental treaties can be monitored (in Swedish). FOA-tidningen, No. 4, December 1990.
Nelander, A., B. Brusmark, A. Gustavsson: Adaptive Speckle Reduction in Imaging Radar. Radarcon 90, Adelaide, 1990.
Ottersten, H., G. Johansson: COMSENS – Satellite System for International Exchange of Data for Treaty Control (in Swedish). RVK 90, 9 – 11 April 1990, Chalmers University of Technology (CUT), Göteborg.
Ottersten, H., B. Brusmark, A. Gustavsson, B. Larsson, A. Nelander: SAR Activities at FOA in 1989 and 1990. Final Report January 1991. FOA No. 91–413/L, Linköping, January 1991.